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REPORT NO. 248

EXPERIMENTAL DATA FORMING THE BASIS FOR THE BOMBING TABLES BT-100-B-3 FOR THE BOMB, PRACTICE, 100-LB., M38A2

by

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Ellen Boyle

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U.S. ARMY ABERDEEN RESEARCH AND DEVELOPMENT CENTER
BALLISTIC RESEARCH LABORATORIES
ABERDEEN PROVING GROUND, MARYLAND

Ballistic Research
Laboratory Report No. 248

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Aberdeen Proving Ground, Md.
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EXPERIMENTAL DATA FORMING THE BASIS FOR THE BOMBING TABLES BT-100-B-3 FOR THE BOMB, PRACTICE, 100-LB., M38A2

Abstract

This report records the essential data on which the bombing tables BT-100-B-3 are based. A short description of the bomb is given as well as the mechanical constants of the bombs used. The methods used in range bombing and the methods of obtaining essential data are described. The methods used to determine the ballistic coefficients as well as the methods used in constructing the bombing tables are also given. Graphs showing the results of range bombing and graphs showing the fitted C : Y relations are included.

1. Purpose of Report

The purpose of this report is to record the essential details of the experimental work, the computing methods and the experimental data upon which the bombing tables BT-100-B-3 for the Bomb, Practice, 100-lb., M38A2 are b

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II. Description of Bombs

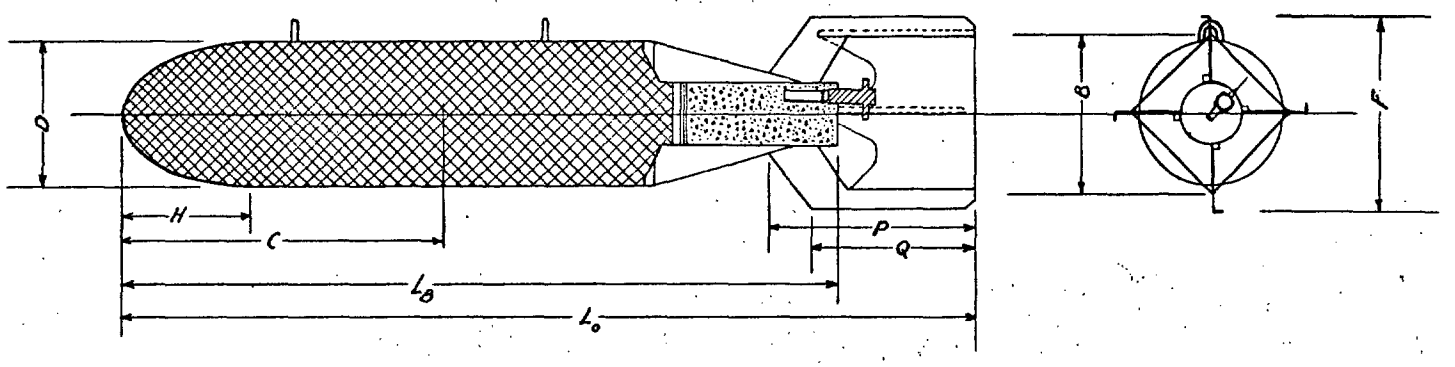
The Bombs, Practice, 100-lb., M38A2 used in range bombing for the bombing tables BT-100-B-3 were made in accordance with Ordnance Department Drawing Number No. 82-0-23 dated December 24, 1937and revised April 29, 1938.

III. Preparation of Bombs

The following page gives an outline drawing of the Bomb, Practice, 100-lb., M38A2 with weights and measurements which were prescribed for range bombing and obtained from observations.

The bomb is made of relatively thin sheet metal and is stored and shipped to the place of issue empty to keep handling

PHYSICAL CHARACTERISTICS
BOMB, PRACTICE, 100-LB., M38A2
ORD. NO. 82-0-23 REV. 4-29-38



PRINCIPAL DIMENSIONS

DIMENSION	INCHES	CALIBERS	REMARKS
D	8.0	1.00	AS GIVEN ON DRAWING
B	8.5	1.06	AS GIVEN ON DRAWING
F	10.75	1.34	AS GIVEN ON DRAWING
L_o	47.5	5.94	AS GIVEN ON DRAWING
L_B	40.6	5.08	AS GIVEN ON DRAWING
H	7.1	0.89	AS GIVEN ON DRAWING
P	11.4	1.42	AS GIVEN ON DRAWING
Q	9.1	1.14	AS GIVEN ON DRAWING
C	18.14 σ=0.242	2.27	MEAN FROM RANGE BOMBING
C	18.16 ± .25	OF BODY ASSEMBLY AS PRESCRIBED FOR RANGE BOMBING WITH TOLERANCE	

COMPONENTS AND WEIGHTS

COMPONENTS		WEIGHT (LB.)	REMARKS
BODY ASSEMBLY	BODY	15.7	AS GIVEN ON DRAWING INCLUDING SUSPENSION LUGS AND FINS
	SPOTTING CHARGE ASSEMBLY	1.25	LESS SPOTTING CHARGE
	SPOTTING CHARGE	3.0	BLACK POWDER (SODIUM NITRATE)
	FILLER	80	SAND - AS GIVEN ON DRAWING
COMPLETE AS DROPPED		100	AS GIVEN ON DRAWING
COMPLETE AS DROPPED		99.3 σ=0.85	MEAN FROM RANGE BOMBING

EXPECTED MAXIMUM VARIATION IN WEIGHT AS LOADED = ±2.57

RATIO: WEIGHT OF BURSTING CHARGE: WEIGHT AS DROPPED = ——

EXPERIMENTAL DESIGNATION: | STANDARDIZED BY: OCM

and shipping costs as low as possible. At the point of issue it is loaded to weight with sand and the spotting charge M1A1 is assembled to it before it is turned over to the Air Corps for use. In order to obtain the highest uniformity of flight of which the bombs are capable it is necessary that the variation in mechanical constants from bomb to bomb be kept as small as possible. In order to accomplish this, the bombs used in these range bombings were loaded with a mixture of sand and cinders in which the proportion of these two materials was adjusted to give the mixture a density such that the specified weight of the completely assembled bomb was obtained when the cavity of the bomb was completely filled. Before being loaded into the bomb the mixture was carefully blended in order to secure a uniform density.

The adequacy of this method of loading is indicated by the evidence cited in the next paragraph of this report and the relatively narrow probable error of forecast bands for the fitted relations between the ballistic coefficients and the altitude of release. These relations and the corresponding probable error of forecast bands are shown in Appendix D. If it is desired to obtain results of equal precision in the field it is recommended that a similar method of loading be prescribed. Failure to employ a systematic control in loading results in a wide dispersion in the mechanical constants of bombs and correspondingly wide dispersion in their flight characteristics.[1]

IV. Mechanical Constants of Bombs

The mechanical constants of each bomb were determined before it was loaded into the airplane. The detailed results of these measurements are given in Appendix A. A summary of the results obtained is given in the table below.

[1] A more complete description of the method used in order to control the mechanical constants of the bombs used in the range bombing program is given in a memorandum prepared in the Ballistic Research Laboratory: "Procedure for Determination of the Mechanical Constants of Bombs".

	m Weight Complete as Dropped lb.	$\bar{x}$ Distance of Center of Gravity from Nose in.	I_L Moment of Inertia about Longitudinal Axis[1] lb.ft.^{2}	I_T Moment of Inertia about Transverse Axis through Center of Gravity lb.ft.^{2}
Mean	99.3	18.14	5.410	76.06
Standard Deviation	0.85	0.24	0.052	1.31
Maximum	102.0	18.76	5.546	79.50
Minimum	98.0	17.75	5.294	72.64
Number of Bombs	99	99	41	99

These statistics refer to all bombs for which a ballistic coefficient with respect to any element was obtained. The actual variation in weight of these bombs does not affect the flight characteristics of the bombs sufficiently to cause a variation in ballistic coefficient large enough to be detected by the methods for estimating the ballistic coefficient which were used in the reduction of the field data. The variation in center of gravity position and moments of inertia would, if sufficiently in excess of that for the present bombs, affect the yaw of the bombs and thereby the dispersion in the elements range, time of flight and trail. The small dispersion in the mechanical constants for these bombs indicates the efficacy of the method of loading described in this report.[2]

V. Description of the Range Bombing

The bombs in this range bombing program were dropped from the B18, B-4, B-4A, B-18A and B-17B airplanes at a target anchored in Bush River in such a position that the release point was in the fields of view of the Vertical and Oblique Cameras Obscura. The direction of the approach to the release point on all runs was from southeast to northwest within approximately 15°.

On all approaches on which bombs were dropped, horizontal flight was maintained as nearly as possible. In the case of the B-18, B-18A, B-4 and B-4A the piloting was done by manual control. In the case of the B-17B airplane the piloting was done by automatic control.

[1] The spotting charge assembled to the Bomb, Practice, 100-lb., M38A2, was modified after 41 measures of I_L were made. The adapter used to permit axial rotation of the bomb in order to measure I_L could no longer be used and consequently only 41 measures of this moment of inertia were made.

[2] A more complete description of the method followed in controlling the mechanical constants is given in Ballistic Research Laboratory Report No. 190: "The Computation of the Mechanical Constants of Bombs".

In these airplanes the bomb racks are so arranged that the longitudinal axis of the bomb is nearly parallel to the thrust line of the airplane. Hence the initial yaw of the bomb in the vertical plane is nearly equal to the angle of attack of the airplane.

On all approaches with the B-18 and the B-18A airplane the bombs were carried in the rear bank of the bomb racks. The center line of this rack is 12.8 feet to the rear of the point formed by the junction of the front edge of the wing with the fuselage of the airplane at which point the airplane is plotted in the cameras obscura. In the B-4 airplane there is a single bank of bomb racks. The corresponding distance is 3.7 feet.[1] In the B-17B airplane the corresponding distance is 6.4 feet for all the bomb rack stations used in range bombing.

All bombs were dropped according to the current standard bombing practice of the Air Corps using the current standard bomb sight and a target in Bush River as an aiming point. The adequacy of the bombing technique is indicated by the results shown in Appendix B. The displacement of the center of impact with respect to the target results in part from the fact that the bombing tables available to the bombardier were based on roughly approximated values of the ballistic coefficients and, for the purpose of this report, are of no special significance. The dispersion about the center of impact and other data summarized in Appendix B are, however, of considerable interest.

The bombs dropped were divided into groups and the endeavor made to make the altitude and air speed within a group approximate as nearly as possible to certain specified values. These values were described as the standard altitude and standard air speed.[2]

The number of bombs in each group and the standard altitude and air speed for each group are given in Appendix D. The reasons for the selection of these standard altitudes and air speeds are given in sections VI and IX of this report.

[1] The effect of the bomb bay release position on the estimated values of the ballistic coefficients is discussed in Ballistic Research Laboratory Report No. 136: "First Progress Report: On the Method of Reduction of Observations on the Elements of Bomb Trajectories".

[2] Compare the usage of these terms for statistical purposes in Sections VIII and IX of this report.

The range bombing was conducted by the following:

Pilots:

Capt. D. W. Watkins, A.C.
Capt. C. S. Thorpe, A.C.
First Lt. L. H. Tull, A.C.
First Lt. B. A. Schreirer, A.C.
Second Lt. C. A. Peterson, A.C.
W.O., J. A. Lee, Sr.
Master Sgt. S. C. Smink, A.C.

Bombardiers:

Capt. C. S. Thorpe, A.C.
First Lt. M. F. Summerfelt, A.C.
Master Sgt. S. C. Smink, A.C.

Proof Officers:

First Lt. R. G. Butler, O.D.
First Lt. J. H. Weber, O.D.
First Lt. J. A. Barclay, Jr., O.D.
First Lt. J. D. Armitage, O.D.
First Lt. J. G. Shinkle, O.D.

VI. Ground Observations

The primary ground observational equipment employed was the Camera Obscura Installation.[1] The position of the aircraft in space and its components of velocity were fundamental data obtained by reduction of observations made with this equipment.

The field data for determination of times of flight were secured by the chronograph installation housed in the Vertical Camera Obscura. The instants of release and impact were recorded by this chronograph - hydrophone system which has been in use in the present form since 1937.[2]

[1] The basic description of the Camera Obscura Installation is given in the "First, Second and Third Progress Reports on Bomb Trajectory Study by the Camera Obscura Method" by Frank Short, F. V. Ludden and S. P. Willan. The equipment has been extensively modified and improved during 1938 and the current equipment and accuracy are described in the Ballistic Research Laboratory Report No. 144: "First Progress Report: On the Accuracy of the Camera Obscura Installation for Obtaining the Initial Data of Bomb Ballistics".

[2] The calibration of the chronograph-hydrophone system and the measurement of the systematic errors to which it is subject were carried out in 1938 and are described in Ballistic Research Laboratory Report No. 130: "On the Measurement of the Time of Flight of Bombs". The absolute accuracy and internal precision of the method in actual practice has been recently determined and the results are given in Ballistic Research Laboratory Report No. 211: "Comparison of Measures of the Time of Flight of Bombs by the Camera Obscura Chronograph and the Western Electric Clock".

The coordinates of the impacts referred to the camera coordinate system were obtained by the ground observers by means of three azimuth instruments on towers along the shore of Bush River and furnished to the Bombing Unit of the Ballistic Research Laboratory. The dispersion data with reference to the target, the reduced meteorological data for securing corrections to the elements tabulated in the bombardier's approximate bombing tables, and the corrections obtained from these meteorological data were also provided by the ground observers. The latter graphically summarized results are given in Appendix B, "Primary Results of Range Bombing".

The field data necessary for the reduction of the effects of non-standard meteorological conditions were obtained from two sources. The data secured by the camera observers were the coordinates on the camera plotting boards of smoke puffs at regular intervals for a series of altitudes, the velocity and direction of the wind at the surface of the ground and the barometric pressure of the air at the surface of the ground. The data secured by the Range Observation Section observers were the spatial positions of a balloon at regular intervals and the velocity and direction of the wind at the surface of the ground. The temperature and barometric pressure at a series of altitudes above the ground were obtained from the bombing flight records of the bombardier. These data were partially reduced by the Range Observation Section and were furnished to the Bombing Unit in the form of tables of:

(1) The actual wind components, and

(2) The density of the air relative to standard ordnance air density structure, each at a series of altitudes.

The wind components were taken as positive along the bombing lane and to the right of the bombing lane. The bombs were dropped during the interval between two wind measurements.

Field data on range bombing with the Bomb, Practice, 100-lb., M38A2 were obtained in part from the program cafried out between May 21, 1937 and May 25, 1938. A systematic bombing program was selected containing four altitude groupingss at 6,000, 9,000, 12,000 and 15,000 feet and carried out between March 9, 1938 and May 25, 1938. The advance of ballistic theory and increased accuracy of measurement during 1938 and

1939 showed that better results can be obtained from groupings at a great altitude of release, a central altitude and a low altitude. Consequently the range bombing program for this bomb was extended during 1939 to include groups at altitudes of release of 20,000 feet and 2,000 feet. These bombs were dropped during the interval between May 3, 1939 and July 17, 1939. In addition, data drawn from the program for determination of the effect of speed of release upon ballistic coefficient for the M38A2 at 7,000 feet altitude of release have been employed. This program was carried out between October 31, 1938 and November 10, 1938. On June 21 and July 5, 1940 range bombing was obtained at an approximate altitude of 25,000 feet. Field data were obtained for determinations of range and time of flight for 99 bombs. Trail determinations were made from the reduced ranges and times of flight when it was possible. A total of 82 times of flight and 82 trails were obtained.

VII. Reduction of Field Data

The data secured by the ground observers at the cameras were utilized to obtain the position and velocity of the airplane at the instant of release. The data secured by the ground observers at the azimuth instruments were utilized to obtain the position of impact of the bombs. The time interval resulting from the chronograph strip was employed to determine the uncorrected interval in time. These data were then corrected for instrumental errors.[1]

VIII. Determination of Ballistic Coefficient

The reduction of the field data furnishes values of the range and time of flight corresponding to a certain set of known values of altitude and air speed, but containing the effects of departures from standard ballistic table conditions.[2] The preparation of a bombing table requires a set of elements which are correct under standard bombing table conditions. The effects of departures from standard bombing table conditions must in the main be removed from the unreduced ranges and times of flight. When standard ballistic table conditions differ from standard bombing table conditions, the effects of these differences are allowed to remain in the reduced ranges and times of flight. The preparation of the bombing table requires the equivalent of a knowledge of the range and time of flight corresponding to all attainable altitudes and air speeds. The procedure is to determine values of the

[1] The character of these instrumental errors is discussed in Ballistic Research Laboratory Reports No. 144, 130 and 211, previously cited.

[2] Standard ballistic table conditions and standard bombing table conditions are discussed and compared in Ballistic Research Laboratory Report No. 145: "On the Theory of Motion of the Bomb".

ballistic coefficients for the observed elements and compute bombing table elements for the other cases by interpolation or extrapolation of the ballistic coefficients.[1]

The computation of the ballistic coefficients is carried out by means of a Bomb Ballistic Reduction Table.[2] The standard ballistic table conditions under which the Bomb Ballistic Reduction Table is computed include the assumption that the only air force acting on the bomb is the drag and that this depends on velocity according to the Gâvre law. Because of these and other differences between standard ballistic table conditions and standard bombing table conditions, there occur not only variations in C with altitude and air speed but the value of C required to give the correct range is different from that required to give the correct time of flight and that for trail is different from either.[3]

In accordance with these principles the ballistic coefficients corresponding to the ranges, times of flight, and trails were then deduced for each individual bomb. From these coefficients the ranges, times of flight and trails were computed for the standard altitude and standard air speed of the group to which the bomb belonged. These are called the "standard ranges", "standard times of flight" and "standard trails", or in general the "standard elements" and are given in Appendix C together with the corresponding ballistic coefficients. This appendix also lists the program, the group, the serial number stamped on the bomb, the date of release and the run number which is called "Bomb No." in "Results of Range Bombing" contained in Appendix B. The last two provide for comparison with Appendices A and B.

The standard elements and the ballistic coefficients corresponding thereto contain the effects of certain unknown instrumental inaccuracies and of certain departures from standard bombing table conditions which it was not feasible to remove in advance. However, the effects of these sources of dispersion were partially removed by the process used for the construction of the bombing table.

[1] The method of reduction of field data in order to obtain ballistic coefficients with respect to range, time of flight and trail has undergone considerable evolution. The reports from which the present methods were developed include: Ballistic Research Laboratory File E-IV-3: "Explanations and Comparisons of the Camera Obscura Methods of Computation", "Computation of Firing Tables for the U.S. Army" and Ballistic Research Laboratory Report No. 136, previously cited.

[2] The table used in reduction of the data discussed in this report was prepared in the Ballistic Research Laboratory.

[3] A discussion of the ballistic coefficients corresponding to range, time of flight and trail is given in Ballistic Research Laboratory Report No. 143: "Errors in Trail Resulting From Ignoring Either the Measured Range or the Measured Time of Flight".

IX. Construction of Tables

The experimental data from which the ballistic coefficients with respect to range, time of flight and trail were determined, fell into 8 altitude groups. The groups were for standard release altitudes of 25,000, 20,000, 15,000, 12,000, 9,000, 7,000, 6,000 and 2,000 feet. The groups at 15,000, 12,000, 9,000 and 6,000 feet were employed in construction of the Bombing Table BT-100-B-1. They were all obtained during 1938. The 7,000 foot groups were obtained incidentally to the range bombing program undertaken to determine the effect of speed of release upon ballistic coefficient. The later bombing programs were determined uniformly for release altitudes of 2,000, 10,000 and the maximum obtainable since it was found that this plan resulted in the greatest amount of ballistic information with the greatest economy in the bombing program. Consequently the range bombing program of 1939 added the groups at 20,000 and 2,000 feet. In 1940 range bombing was carried out for an altitude group of 25,000 feet. The dependence of the ballistic coefficients upon altitude of release were thus well determined.

The mean standard elements for a standard true air speed and altitude were determined for each altitude group. The mean standard element is the arithmetic mean of the individual standard elements. The individual standard elements used in computing the mean standard elements had of course, been reduced to the group standard altitude and true air speed. The use of the mean standard elements reduces the influence of accidental errors in the individual standard elements upon the elements tabulated in the bombing table. The ballistic coefficients corresponding to these mean standard elements were then deduced. The forms of the functional dependence upon altitude of the three ballistic coefficients have been derived theoretically and verified empirically.[1] The lift is the cause mainly responsible for the character of the variation of the ballistic coefficients with altitude. The lift is due to the yaw arising from the initial angular velocity of the tangent to the trajectory. The effects of lift are allowed to remain in the ballistic coefficients corresponding to the mean standard elements. The functional relations referred to are:

[1] The derivation of the form of these relations between the ballistic coefficient and the altitude of release is discussed in Ballistic Research Laboratory Report No. 145, previously cited.

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$$C_{X_y} = \frac{C_{X_\infty}}{1 + \frac{k_X C_{X_\infty}}{\sqrt{Y}}}$$

$$C_{T_y} = \frac{C_{T_\infty}}{1 + \frac{k_T C_{T_\infty}}{\sqrt{Y}}}$$

$$C_{\lambda_y} = \frac{C_{\lambda_\infty}}{1 + \frac{k_\lambda C_{\lambda_\infty}}{\sqrt{Y}}}$$

These curves each contain two empirical quantities k and C_∞. The subscript ∞ refers to the mean effective ballistic coefficient for infinite altitude, and k is a parameter determining the shape of the curve.

A new procedure for estimating the values of C_{X_∞}, C_{T_∞}, C_{λ_∞}, k_X, k_T and k_λ was introduced between the date when bombing tables BT-100-B-2 were issued and the date when bombing tables BT-100-B-3 were issued.[1] The new procedure involved two principal modifications in the method of estimation:

(1) An improved assignment of weights to the altitude groups, and

(2) Direct minimization of the weighted squares of the residual differences between the mean standard elements and those elements which would result from the use of the bombing tables. This modification has resulted in much smaller probable ballistic errors for bombing tables.[2] The improvement is shown by the reduced magnitude of the differences between the observed mean standard ranges, times of flight and trails and those elements which would result from employment of these tables. The values C_{X_∞}, C_{T_∞}, C_{λ_∞}, k_X and k_λ were deduced by this new procedure: k_T was shown to be without significance in the present instance.

[1] A brief description of the new procedure is given in Ballistic Research Laboratory Report No. 224: "Experimental Data Forming the Basis for the Bombing Tables BT-1000-A-1 for the Bomb, Demolition, 1000-lb., M44".

[2] The ballistic error is a term originally used by British ballisticians to denote the difference between the bombing table range and the mean standard range for the same conditions. The ballistic error is denoted by $X - X_f$ in this report.

The values were:

$$C_{X_\infty} = 1.223 \; ; \; C_{T_\infty} = 1.290 \; ; \; C_{\lambda_\infty} = 1.171$$

$$k_X = -20.692; \; k_T = 0 \; ; \; k_\lambda = -17.889$$

The observed and fitted ballistic coefficients are compared in Tables 1, 2 and 3 of Appendix D. The relations between the fitted ballistic coefficients and the altitude of release are shown in Plots I, II and III in Appendix D. The fitting provides for obtaining the ballistic coefficient for any altitude of release. The actual points on the plots in Appendix D are shown by dots and their probable errors by horizontal strokes placed on the sides of the dots. The computed C : Y relations are shown by heavy lines. The dotted lines furnish the probable error of forecast. The band included by these lines is determined by addition and subtraction of the probable error of the computed C : Y relation from the curve.

The construction of the table of DS followed general instructions given in file 00 063.2/4524 (Confidential). The trail angles, times of flight and dropping angles tabulated were obtained by interpolation with the fitted C : Y relations in the Bomb Ballistic Auxiliary Tables (Provisional) computed in the Ballistic Research Laboratory. These tables give trail angles, times of flight and dropping angles as functions of the altitude of release, Y, the calibrated indicated air speed, V, or true ground speed, V_g, and the reciprocal ballistic coefficient, $\frac{1}{C}$. The intervals of the arguments used in the Bomb Ballistic Auxiliary Tables are the same as those used in the present series of abridged bombing tables. The small differences between the observed mean standard ranges, times of flight and trails and those elements which would result from employment of these tables are shown by the columns $X - X_f$, $T - T_f$ and $\lambda - \lambda_f$ given in Tables 1, 2 and 3 of Appendix D. These differences are compared with the probable errors of the observed mean standard elements in Plots IV, V and VI of Appendix D. The importance of employment of the fitted C_{X_y} : Y, C_{T_y} : Y and C_{λ_y} : Y curves is shown by the small magnitudes of these differences.

The bombing tables BT-100-B-3 are a revision of bombing tables BT-100-B-2. The ranges of arguments included in these bombing tables are indicated in the table below:

Element	Speed mi./hr.		Altitude ft.	
	Minimum	Maximum	Minimum	Maximum
Trail Angle (Calibrated Indicated Air Speed)	100	250	1800	35000
DS (Calibrated Indicated Air Speed)	160		1800 1800	21000 31000
Time of Flight (Calibrated Indicated Air Speed)	160		1000	35000
Dropping Angle (Ground Speed)	100	250	100	10000

The Introduction to the bombing tables BT-100-B-3 has been shortened to one page and contains only the most essential information.

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Appendix A

Mechanical Constants of Bombs

Appendix A

Mechanical Constants of Bombs

Program, Group, Serial Number	Date of Release, Run Number	m Weight Complete as Dropped lb.	$\bar{x}$ Distance of Center of Gravity From Nose in.	I_L Moment of Inertia About Longitudinal Axis lb.ft.^{2}	I_T Moment of Inertia About Transverse Axis Through Center of Gravity lb.ft.^{2}
KS-138L-9	3/9/38--1	99	17.75	5.480	75.24
8	2	99	17.87	5.438	73.78
12	3	99	17.75	5.384	74.36
10	4	99	17.87	5.438	75.06
11	5	99	17.87	5.390	74.99
7	6	99	17.87	5.428	73.84
KS-138-13	3/21/38-1	99	18.00	5.404	73.73
18	2	99	17.87	5.410	77.80
14	3	99	18.00	5.412	75.12
17	4	99	17.81	5.464	76.12
16	6	99	17.81	5.386	76.53
19	4/25/38-1	100	17.75	5.434	74.96
20	2	100	18.25	5.402	77.02
22	4	100	18.12	5.408	76.60
23	5	100	17.81	5.452	75.39
24	4/28/38-1	99	18.06	5.464	76.10
26	3	99	17.94	5.524	73.31
31	4	99	17.94	5.425	76.02
37	5	99	18.37	5.360	76.60
32	6	99	18.03	5.411	75.63
28	5/2/38--1	99	18.12	5.383	76.48
36	2	99	18.12	5.312	76.46
33	3	99	18.37	5.294	76.15
37	4	99	17.87	5.353	75.31
34	5	99	18.00	5.320	75.70
38	5/3/38--1	99	18.25	5.396	75.40
39	2	99	18.00	5.470	72.68
40	3	99	18.12	5.410	75.85
41	4	99	17.94	5.392	75.66
42	5	99	17.94	5.406	78.12
43	6	99	18.06	5.382	75.98
35	5/6/38--1	99	17.87	5.395	76.85
48	2	99	18.00	5.445	75.55
44	3	99	18.50	5.378	75.72
49	4	99	18.22	5.546	75.80
46	5	99	18.00	5.316	76.82
53	5/25/38-1	99	18.45	5.483	75.35
54	2	99	18.60	5.361	74.27
55	3	99	18.55	5.425	74.20
52	4	99	18.60	5.429	75.48
51	5	99	18.40	5.395	74.39

Mechanical Constants of Bombs

Program, Group, Serial Number	Date of Release, Run Number	m Weight Complete as Dropped lb.	$\bar{x}$ Distance of Center of Gravity From Nose in.	I_L Moment of Inertia About Longitudinal Axis lb.ft.^{2}	I_T Moment of Inertia About Transverse Axis Through Center of Gravity lb.ft.^{2}
RX-138-107	10/31/38--1	100.0	18.32		76.39
112	2	100.8	18.40		77.77
109	3	99.5	18.43		78.47
110	4	100.0	18.50		77.19
111	5	99.8	18.76		78.03
102	1	98.5	18.46		76.66
103	2	99.8	18.57		77.25
104	3	99.0	18.29		76.74
105	4	99.9	18.75		78.61
106	5	99.8	18.40		77.34
108	11/10/38--1	99.5	18.48		77.76
113	2	100.1	18.31		78.45
114	3	99.1	18.42		77.34
115	4	99.5	18.42		77.06
116	5	100.3	18.50		77.85
117	1	100.9	18.23		77.33
118	2	100.8	18.52		77.30
119	3	100.2	18.32		76.89
120	4	100.4	18.45		76.95
121	5	99.5	18.44		78.39
KS-138---1	5/3/39----1	98.0	17.87		75.42
2	2	98.0	18.20		75.09
3	3	99.5	17.89		77.04
4	4	98.0	17.92		76.54
7	5	98.0	18.02		74.63
6	6	99.0	18.22		75.68
9	7	99.0	18.10		75.68
8	8	98.0	18.07		74.83
10	9	98.2	17.96		74.33
5	10	99.0	17.85		75.73
11	5/4/39----1	98.5	17.81		79.50
12	2	100.0	18.22		77.10
13	3	100.0	18.11		77758
14	4	98.0	18.10		77.57
15	5	99.0	18.20		76.87
16	6	98.0	17.90		76.38
17	7	98.0	17.75		76.20
18	8	98.0	18.07		77.52
19	9	98.0	18.25		77.56
20	10	98.2	18.11		76.92

Mechanical Constants of Bombs

Program, Group, Serial Number	Date of Release, Run Number	m Weight Complete as Dropped lb.	$\bar{x}$ Distance of Center of Gravity From Nose in.	I_L Moment of Inertia About Longi-tudinal Axis lb.ft.^{2}	I_T Moment of Inertia About Transverse Axis Through Center of Gravity lb.ft.^{2}
KS-138-1	7/11/39-1	99.0	18.25		74.73
2	2	99.0	18.07		75.33
3	3	99.5	18.14		74.57
4	4	99.5	18.00		75.35
5	5	98.5	18.25		74.45
6	6	99.5	18.14		74.96
7	7	101.0	18.25		75.43
8	8	102.0	18.27		75.90
9	7/17/39-1	102.0	18.10		76.28
10	2	98.0	18.08		72.64
1	6/21/40-1	101.0	18.03		75.75
2	2	101.0	17.91		75.48
4	4	101.0	18.14		75.91
5	5	99.0	17.86		74.87
7	7/5/40--2	100.0	18.01		75.23
8	3	100.0	18.16		75.39
9	4	99.5	18.18		75.62
10	5	100.5	18.01		75.42

Appendix B

Primary Results of Range Bombing

RESULTS OF RANGE BOMBING NO. 1

MARCH 9, 1938 — 100 LB. PRACTICE BOMB M38A2 — AIRPLANE B1

PILOT: CAPT. D. W. WATKINS (1-4), W. O. J. A. LEE (5 & 6) — BOMBARDIER: CAPT. C. S. THORP

SKY: AIR — TRAIL AND D.S. BASED ON C = 1.4

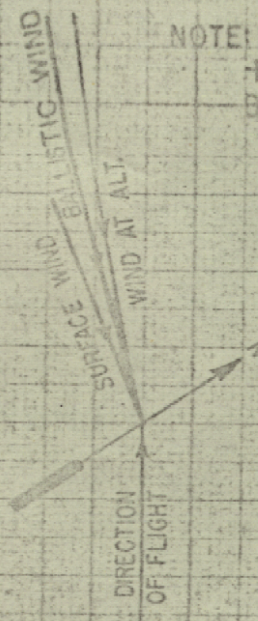
BOMB NO.	TIME OF REL.	ALTITUDE AIR OBS FT	ALTITUDE GRND OBS FT	AIR SPEED CAL IND M/HR	AIR SPEED TRUE AIR OBS. M/HR	AIR SPEED TRUE GRND OBS. M/HR	GRND. SPEED GRND OBS. M/HR	CLIMB-GLIDE AIR OBS FT/MIN	CLIMB-GLIDE GRND OBS. FT/MIN	DEVIATIONS FROM TAR RANGE OVER FT.	RANGE SHORT FT.	DEFLECT RIGHT FT.	L
1	11:05	8810	8800	146	167.3	163.9	105.7		+ 6.6	309			
2	11:05	8810	8800	146	167.3	163.9	105.7		+ 6.6	318			
3	11:15	8840	8813	145	166.2	160.7	102.3		−81.6	270		84	
4	11:25	8810	8773	144	164.9	161.7	103.7		−73.8	204		27	
5	11:35	8800	8769	148	169.5	167.0	108.4		−75.6	144			
6	11:45	8850	8843	148	169.8	165.1	106.8		−63.6	369		30	
									CENTER OF IMPACT	269		4	
									MEAN DEVIATION	63		43	

		TIME 9:51	TIME 1:35
WIND	SURFACE, VELOCITY (M/HR)	7.0	13.0
	AT ALTITUDE, VELOCITY "	56.8	93.7
	BALLISTIC, VELOCITY "	49.6	66.4
	BALLISTIC, AZIMUTH (TO)	298.4°	289.0°
DENSITY	AT SURFACE	1.061	1.046
	BALLISTIC (SURFACE)	1.047	1.037
	BALLISTIC (AIR OBS.)	1.041	1.032

CORRECTIONS USED

MILS IN	RANGE	DEF
WIND	+25.0	0.4
DENSITY	—	—
TOTAL	+25.0	0.4

NOTE: AN ERRONEOUS RANGE WIND OF +25.0 MILS WAS GIVEN THE BOMBARDIER



RESULTS OF RANGE BOMBING NO. IA

MARCH 9, 1938 — 100 LB. PRACTICE BOMB M38A2 — AIRPLANE B18

PILOT CAPT. D. W. WATKINS (1-4), W. O. J. A. LEE (5&6) — BOMBARDIER: CAPT. C. S. THORPE

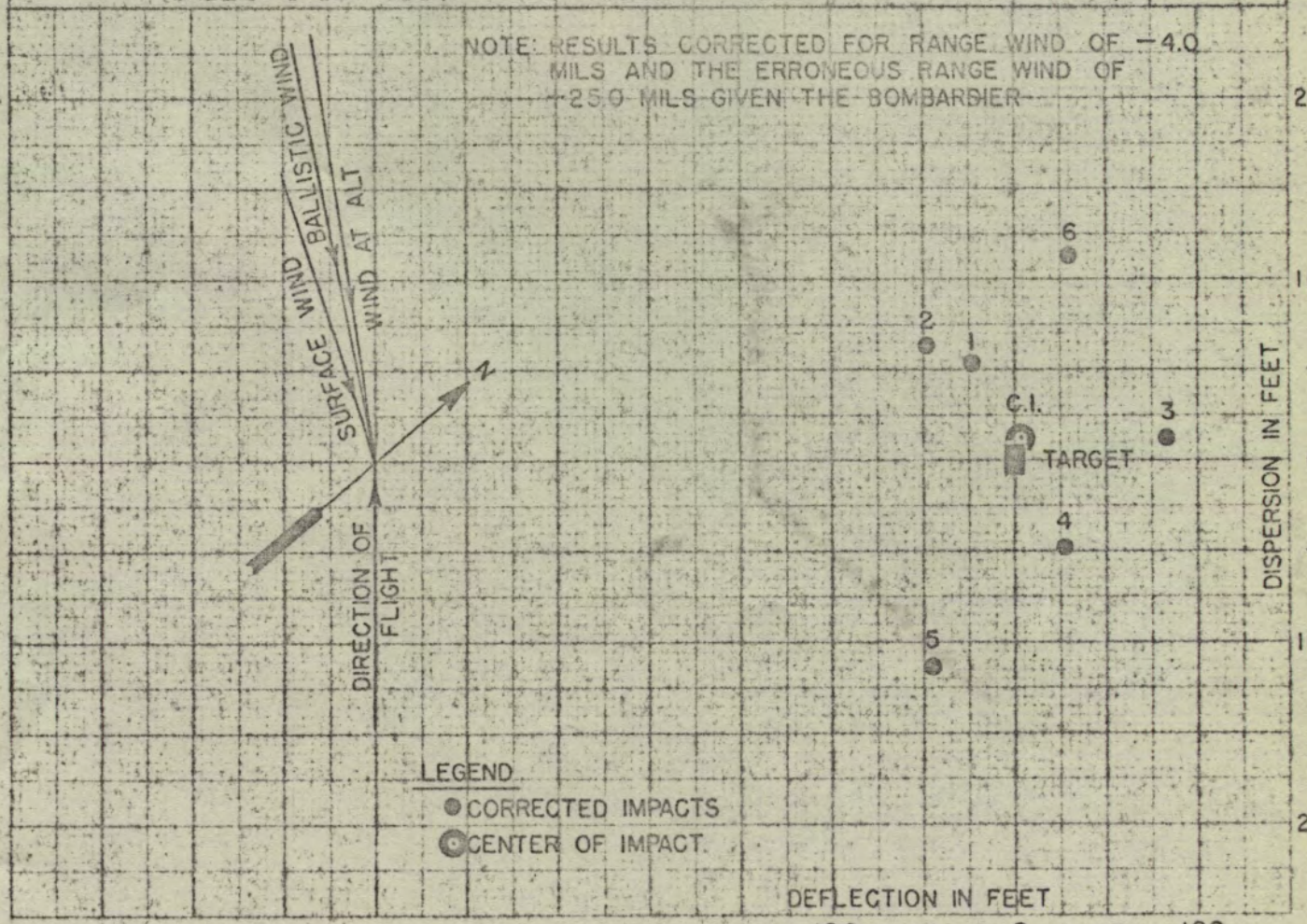
SKY: — AIR: — TRAIL AND D.S. BASED ON C = 1.41

BOMB NO.	TIME OF REL.	ALTITUDE		AIR SPEED			GRND. SPEED	CLIMB-GLIDE		DEVIATIONS FROM TARGET			
		AIR OBS.	GR'ND OBS.	CAL.	TRUE		GR'ND OBS.	AIR	GR'ND	RANGE		DEFLECTION	
				IND.	AIR OBS.	GR'ND OBS.		OBS.	OBS.	OVER	SHORT	RIGHT	LEFT
		FT.	FT.	M/HR	M/HR	M/HR	M/HR	FT/MIN.	FT/MIN.	FT.	FT.	FT.	FT
1	11:05	8810	8800	146	167.3	163.9	105.7		+ 6.6	54			24
2	11:05	8810	8800	146	167.3	163.9	105.7		+ 6.6	63			48
3	11:15	8840	8813	145	166.2	160.7	102.3		-81.6	12		84	
4	11:25	8810	8773	144	164.9	161.7	103.7		-73.8		48	27	
5	11:35	8800	8769	148	169.5	167.0	108.4		-75.6		114		45
6	11:45	8850	8843	148	169.8	165.1	106.8		-63.6	111		30	
CENTER OF IMPACT										13		4	
MEAN DEVIATION										63		43	

		TIME 9:51	TIME 1:35
WIND	SURFACE, VELOCITY (M/HR)	7.0	13.0
	AT ALTITUDE, VELOCITY "	56.8	93.7
	BALLISTIC VELOCITY "	49.6	66.4
	BALLISTIC AZIMUTH (TO)	298.4°	289.0°
DENSITY	AT SURFACE	1.061	1.046
	BALLISTIC (SURFACE)	1.047	1.037
	BALLISTIC (AIR OBS.)	1.041	1.032

CORRECTIONS USED	MILS IN RANGE	MILS IN DEFL.
WIND	—	—
DENSITY	—	—
TOTAL	—	—

NOTE: RESULTS CORRECTED FOR RANGE WIND OF -4.0 MILS AND THE ERRONEOUS RANGE WIND OF -25.0 MILS GIVEN THE BOMBARDIER



RESULTS OF RANGE BOMBING NO. 2

MARCH 21, 1938 — 100 LB PRACTICE BOMB M38A2 — AIRPLANE B18

PILOT W. O. J. A. LEE — BOMBARDIER CAPT. C. S. THORPE

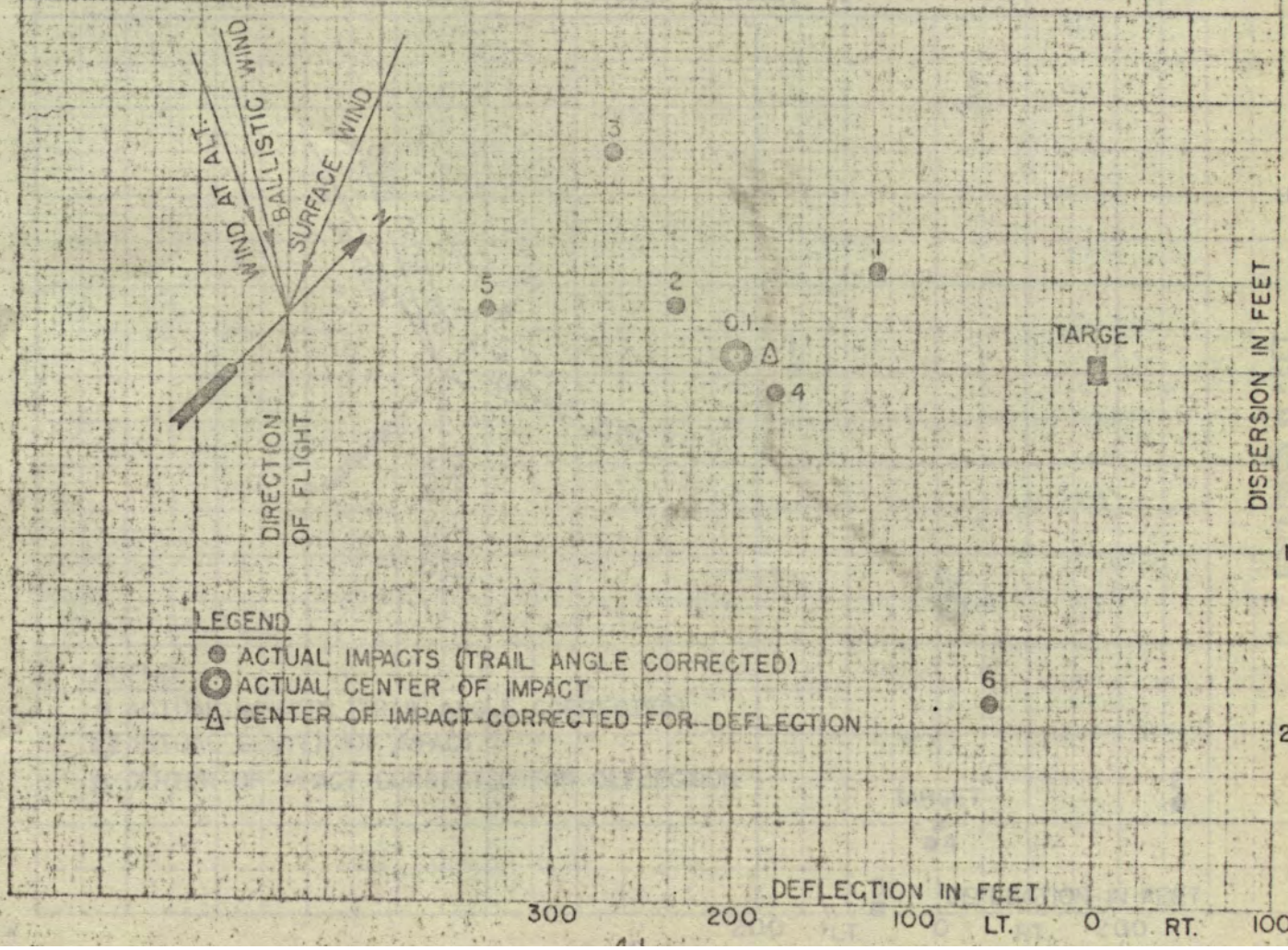
SKY: — AIR: — TRAIL AND D.S. BASED ON C = 1.41

BOMB NO	TIME OF REL.	ALTITUDE AIR OBS. FT.	ALTITUDE GRND OBS. FT	AIR SPEED CAL. IND M/HR	AIR SPEED TRUE AIR OBS M/HR	AIR SPEED TRUE GRND OBS. M/HR	GRND. SPEED GRND OBS. M/HR	CLIMB-GLIDE AIR OBS FT/MIN.	CLIMB-GLIDE GRND. OBS. FT/MIN.	DEVIATIONS FROM TARGET RANGE OVER FT.	RANGE SHORT FT.	DEFLECTION RIGHT FT.	DEFLECTION LEFT FT.
1	10:50	9200	9270	140.7	162.4	159.1	135.7		-196.2	54			123
2	11:00	9200	9261	145.0	167.3	165.4	142.0		-227.4	33			234
3	11:15	9200	9265	146.0	168.5	166.0	142.6		- 85.2	117			270
4	11:30	9180	9255	144.0	166.2	162.8	139.3		- 31.2		15		177
5		9160		140.7	162.4					30			339
6	12:00	9180	9236	140.7	162.4	158.7	135.4		+ 10.2		186		57
DIFFERENTIAL BALLISTIC WIND M/HR.										CENTER OF IMPACT			200
RANGE: -5.5				CROSS: +4.7						MEAN DEVIATION		71	81

	TIME	9:36	1:30
WIND	SURFACE VELOCITY (M/HR)	8.0	6.6
	AT ALTITUDE, VELOCITY	29.6	18.0
	BALLISTIC VELOCITY	23.0	15.8
	BALLISTIC AZIMUTH (TO)	300.7°	307.1°
DENSITY	AT SURFACE	1.004	0.995
	BALLISTIC (SURFACE)	1.009	1.003
	BALLISTIC (AIR OBS.)	0.993	0.990

CORRECTIONS USED

MILS IN	RANGE	DEFL.
WIND	-3.0	2.0R
DENSITY	—	—
TOTAL	-3.0	2.0 R



LEGEND

- ● ACTUAL IMPACTS (TRAIL ANGLE CORRECTED)
- ◎ ACTUAL CENTER OF IMPACT
- Δ CENTER OF IMPACT CORRECTED FOR DEFLECTION

RESULTS OF RANGE BOMBING NO. 5

APRIL 25, 1938 — 100 LB. PRACTICE BOMB M38A2 — AIRPLANE B 18

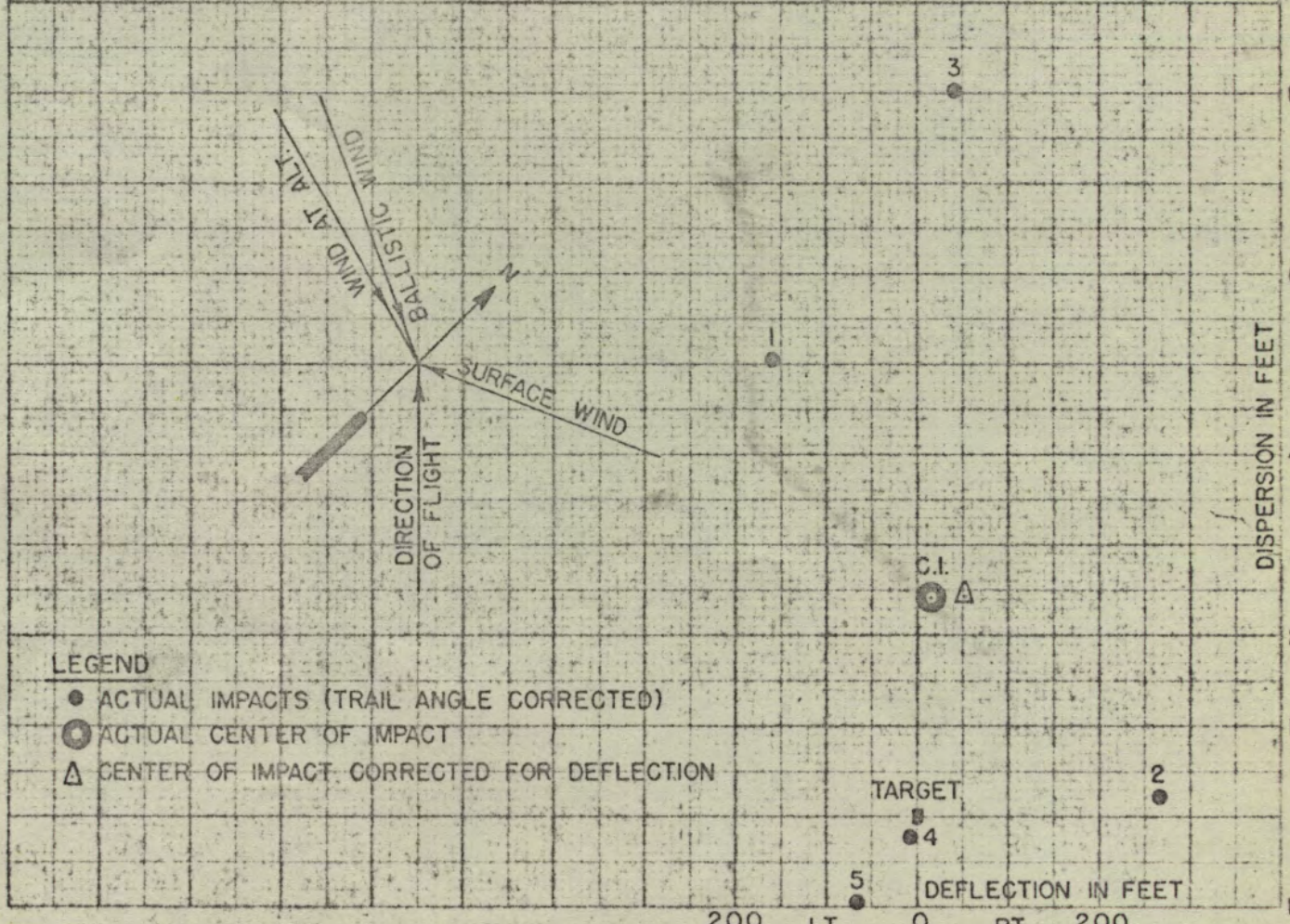
PILOT: CAPT. D. W. WATKINS — BOMBARDIER: CAPT. C. S. THORPE

SKY: — AIR: — TRAIL AND D.S. BASED ON C = 1.60

BOMB NO.	TIME OF REL.	ALTITUDE AIR OBS. FT.	ALTITUDE GRND. OBS. FT	AIR SPEED CAL. IND. M/HR	AIR SPEED TRUE AIR OBS. M/HR	AIR SPEED TRUE GRND OBS. M/HR	GRND. SPEED GRND. OBS. M/HR	CLIMB-GLIDE AIR OBS. FT/MIN.	CLIMB-GLIDE GRND OBS. FT/MIN.	DEVIATIONS FROM TARGET RANGE OVER FT.	RANGE SHORT FT.	DEFLECTION RIGHT FT.	DEFLECTION LEFT FT
1	10:50	12320	12283	144	173.7	174.7	140.9		+23.4	504			159
2	11:00	12340	12301	143	172.5	169.0	137.3		+19.2	21		267	
3	11:06	12320	12263	141	169.9	171.5	140.0		+52.2	801		42	
4	11:20	12340	12296	145	174.9	173.8	143.9		−28.2		24		9
5	11:41	12340	12309	145	174.9	170.0	142.2		+117.6		96		66
6													
DIFFERENTIAL BALLISTIC WIND M/HR.									CENTER OF IMPACT	241		15	
RANGE: −5.7			CROSS: +8.2						MEAN DEVIATION	329		112	

		TIME	10:03	12:35
WIND	SURFACE, VELOCITY (M/HR)		6.0	6.0
	AT ALTITUDE, VELOCITY "		34.0	29.5
	BALLISTIC VELOCITY "		25.2	27.3
	BALLISTIC AZIMUTH (TO)		293.0°	304.3°
DENSITY	AT SURFACE		1.028	1.016
	BALLISTIC (SURFACE)		1.024	1.017
	BALLISTIC (AIR OBS.)		0.996	0.991

CORRECTIONS USED	MILS IN RANGE	DEFL.
WIND	−2.7	3.0 R
DENSITY	+2.2	—
TOTAL	−0.5	3.0 R



RESULTS OF RANGE BOMBING NO. 6

APRIL 28, 1938 — 100 LB. PRACTICE BOMB M38A2 — AIRPLANE B 18

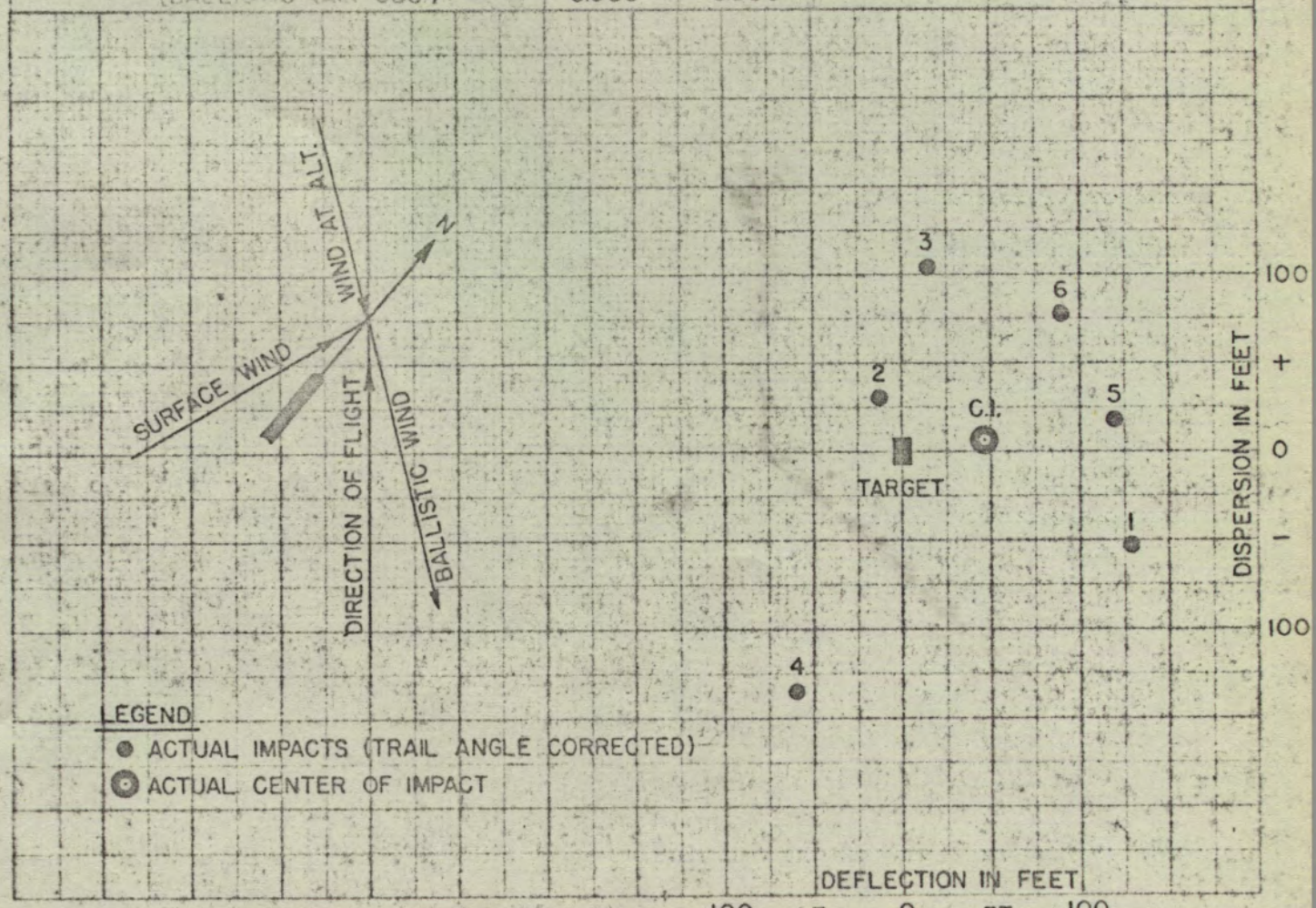
PILOT: LT. L. H. TULL — BOMBARDIER: CAPT. C. S. THORPE

SKY: — AIR: — TRAIL AND D.S. BASED ON C = 1.60

BOMB NO.	TIME OF REL.	ALTITUDE		AIR SPEED			GRND. SPEED	CLIMB-GLIDE		DEVIATIONS FROM TARGET			
		AIR	GRND	CAL.	TRUE			AIR	GRND	RANGE		DEFLECTION	
		OBS.	OBS.	IND.	AIR OBS.	GRND OBS.	GRND OBS.	OBS.	OBS.	OVER	SHORT	RIGHT	LEFT
		FT	FT	M/HR	M/HR	M/HR	M/HR	FT/MIN.	FT/MIN.	FT	FT	FT.	FT.
1	10:55	6270	6162	140	153.7	148.6	143.2		+ 27.6		54	129	
2		6270		141						30			12
3	11:25	6270	6373	143	157.6	158.3	154.2		- 67.2	105		15	
4	11:33	6270	6349	140	154.3	153.3	150.1		-100.2		135		60
5	11:40	6270	6305			154.0	151.4		+143.4	18		120	
6	11:55	6270	6270	148	162.8	168.1	162.7		+110.4	78		90	
DIFFERENTIAL BALLISTIC WIND M/HR.								CENTER OF IMPACT		7		47	
RANGE: -0.7				CROSS: +0.4				MEAN DEVIATION		68		66	

	TIME	9:38	12:00
WIND	SURFACE VELOCITY (M/HR)	14.0	14.0
	AT ALTITUDE, VELOCITY "	9.9	4.1
	BALLISTIC VELOCITY "	9.2	3.3
	BALLISTIC AZIMUTH (TO)	306.5°	261.3°
DENSITY	AT SURFACE	0.998	0.984
	BALLISTIC (SURFACE)	1.003	0.992
	BALLISTIC (AIR OBS.)	0.985	0.980

CORRECTIONS USED		
MILS IN	RANGE	DEF.
WIND	-0.3	0.1 R
DENSITY	+0.1	—
TOTAL	-0.2	0.1 R



RESULTS OF RANGE BOMBING NO. 7

MAY 2, 1938 — 100 LB. PRACTICE BOMB M38A2 — AIRPLANE B18

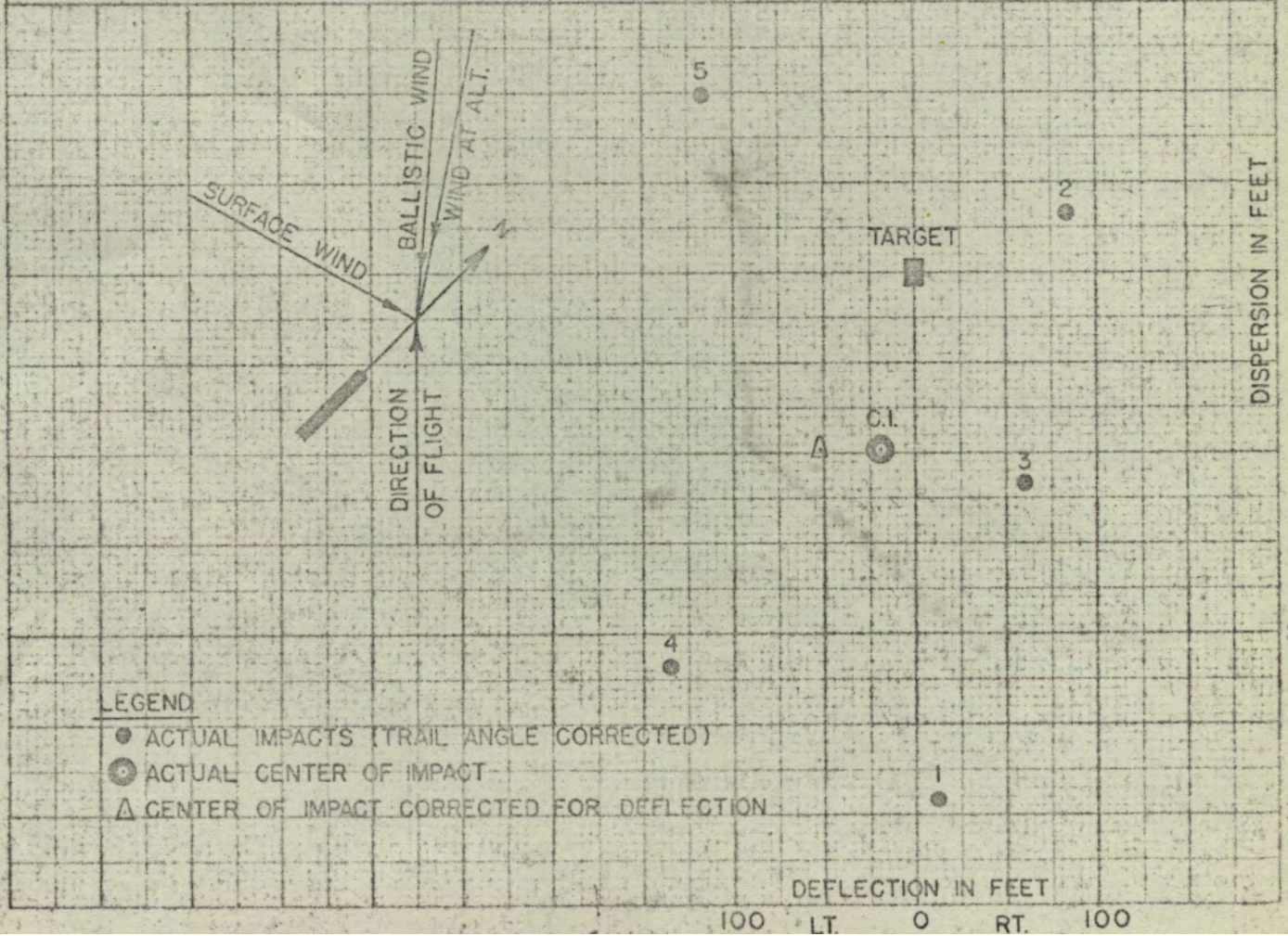
PILOT: W. O. J. A. LEE — BOMBARDIER: CAPT. C. S. THORPE

SKY — AIR: — TRAIL AND D.S. BASED ON C = 1.60

BOMB NO.	TIME OF REL.	ALTITUDE		AIR SPEED			GRND. SPEED	CLIMB-GLIDE		DEVIATIONS FROM TARGET			
		AIR	GRND.	CAL.	TRUE		GRND	AIR	GRND	RANGE		DEFLECTION	
		OBS.	OBS.	IND	AIR OBS.	GRND OBS.	OBS.	OBS.	OBS.	OVER	SHORT	RIGHT	LEFT
		FT.	FT.	M/HR	M/HR	M/HR	M/HR	FT/MIN.	FT/MIN.	FT.	FT.	FT.	FT.
1	11:26	15690	15585	134	170.4	170.0	121.9		+190.8		291	12	
2	11:35	15730	15616	134	170.4	173.0	124.3		− 8.4	33		84	
3	11:50	15710	15607	135	171.7	174.3	124.8		+ 58.8		117	60	
4	11:58	15700	15566	136	172.9	175.8	126.1		+119.4		219		135
5	12:11	15720	15561	138	175.4	178.2	128.3		−236.4	99			117
6													
DIFFERENTIAL BALLISTIC WIND M/HR.								CENTER OF IMPACT			99		19
RANGE: −10.0		CROSS: −5.9						MEAN DEVIATION		132		85	

	TIME	9:50	12:45
WIND	SURFACE, VELOCITY (M/HR)	7.0	14.0
	AT ALTITUDE, VELOCITY "	48.3	51.3
	BALLISTIC VELOCITY "	37.5	37.9
	BALLISTIC AZIMUTH (TO)	321.0°	319.2°
DENSITY	AT SURFACE	0.993	0.985
	BALLISTIC (SURFACE)	1.006	1.002
	BALLISTIC (AIR OBS.)	0.970	0.967

CORRECTIONS USED		
MILS IN	RANGE	DEFL.
WIND	−4.7	2.3 L
DENSITY	−0.2	—
TOTAL	−4.9	2.3 L



RESULTS OF RANGE BOMBING NO. 8

MAY 3, 1938 — 100 LB. PRACTICE BOMB M38A2 — AIRPLANE B 18

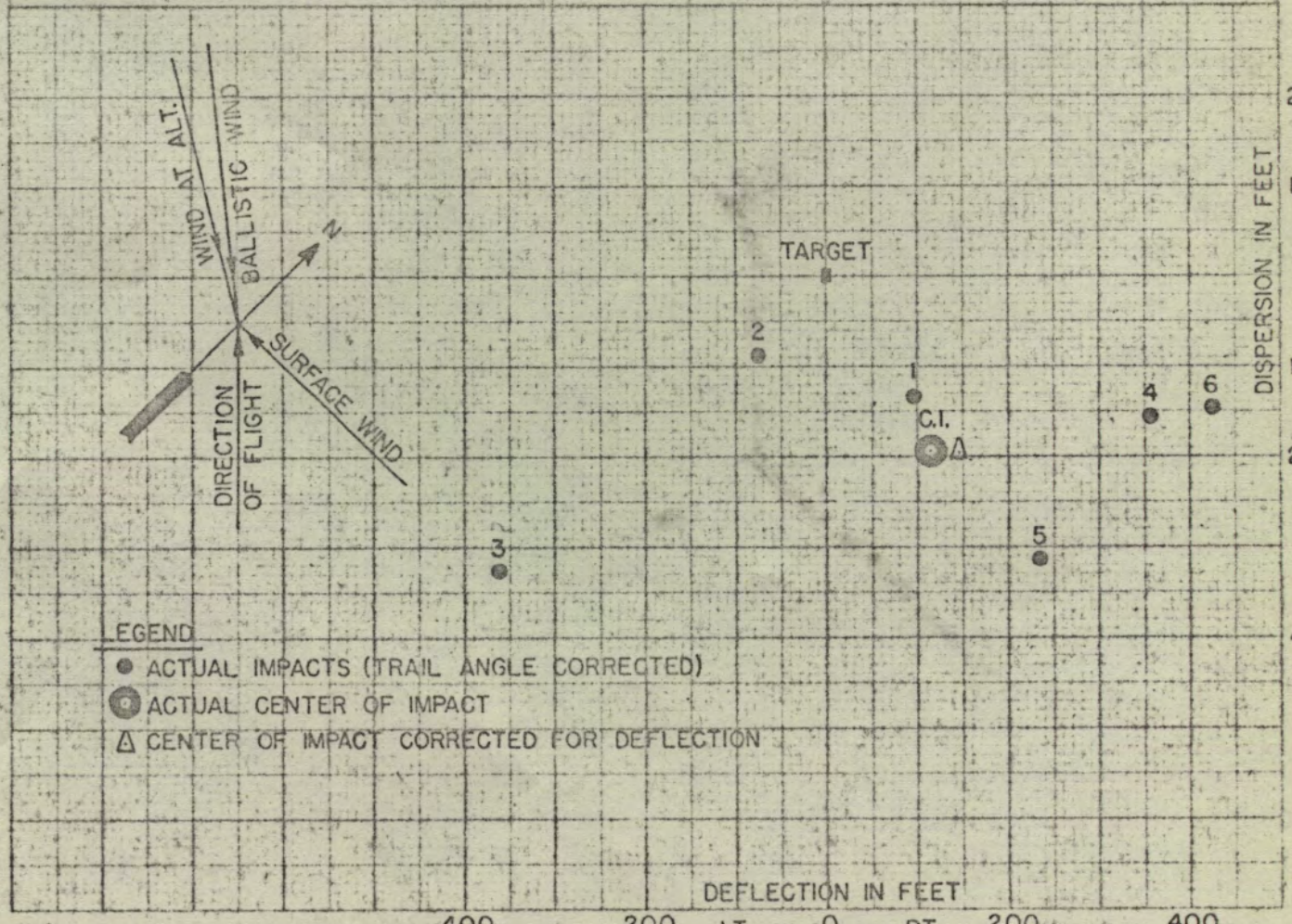
PILOT: W. O. J.A. LEE — BOMBARDIER: SGT. S. C. SMINK

SKY: — AIR: — TRAIL AND D.S. BASED ON C = 1.60

BOMB NO.	TIME OF REL.	ALTITUDE AIR OBS. FT.	ALTITUDE GR'ND OBS. FT.	AIR SPEED CAL IND M/HR.	AIR SPEED TRUE AIR OBS. M/HR.	AIR SPEED TRUE GR'ND. OBS. M/HR.	GR'ND. SPEED GR'ND. OBS. M/HR.	CLIMB-GLIDE AIR OBS. FT/MIN.	CLIMB-GLIDE GR'ND. OBS. FT/MIN.	DEVIATIONS FROM TARGET RANGE OVER FT.	RANGE SHORT FT.	DEFLECTION RIGHT FT.	DEFLECTION LEFT FT.
1	11:15	15690	15655	133	169.3	172.3	130.2		- 24.0		132	96	
2	11:23	15700	15655	135	171.9	170.2	128.0		-252.6		87		75
3	11:32	15650	15598	133	169.2	173.6	131.5		-162.6		327		360
4	11:41	15730	15688	136	173.3	170.4	128.3		- 22.8		156	357	
5	11:48	15700	15634	135	171.9	173.4	131.0		- 61.8		312	237	
6	11:55	15730	15661	135	171.9	174.1	132.1		- 64.2		147	426	
DIFFERENTIAL BALLISTIC WIND M/HR.							CENTER OF IMPACT				194	114	
RANGE: -5.1			CROSS: +5.6				MEAN DEVIATION				84		227

	TIME	9:56	2:08
WIND	SURFACE, VELOCITY (M/HR)	9.0	5.0
	AT ALTITUDE, VELOCITY "	38.3	45.3
	BALLISTIC VELOCITY "	32.2	38.9
	BALLISTIC AZIMUTH (TO)	309.1°	306.9°
DENSITY	AT SURFACE	0.991	0.978
	BALLISTIC (SURFACE)	1.005	0.998
	BALLISTIC (AIR OBS.)	0.967	0.965

CORRECTIONS USED	MILS IN RANGE	DEFL.
WIND	-2.4	2.1 R
DENSITY	-0.3	—
TOTAL	-2.7	2.1 R



RESULTS OF RANGE BOMBING NO. 9

MAY 6, 1938 — 100 LB. PRACTICE BOMB M38A2 — AIRPLANE B18

PILOT: W. O. J. A. LEE — BOMBARDIER: SGT. S. C. SMINK

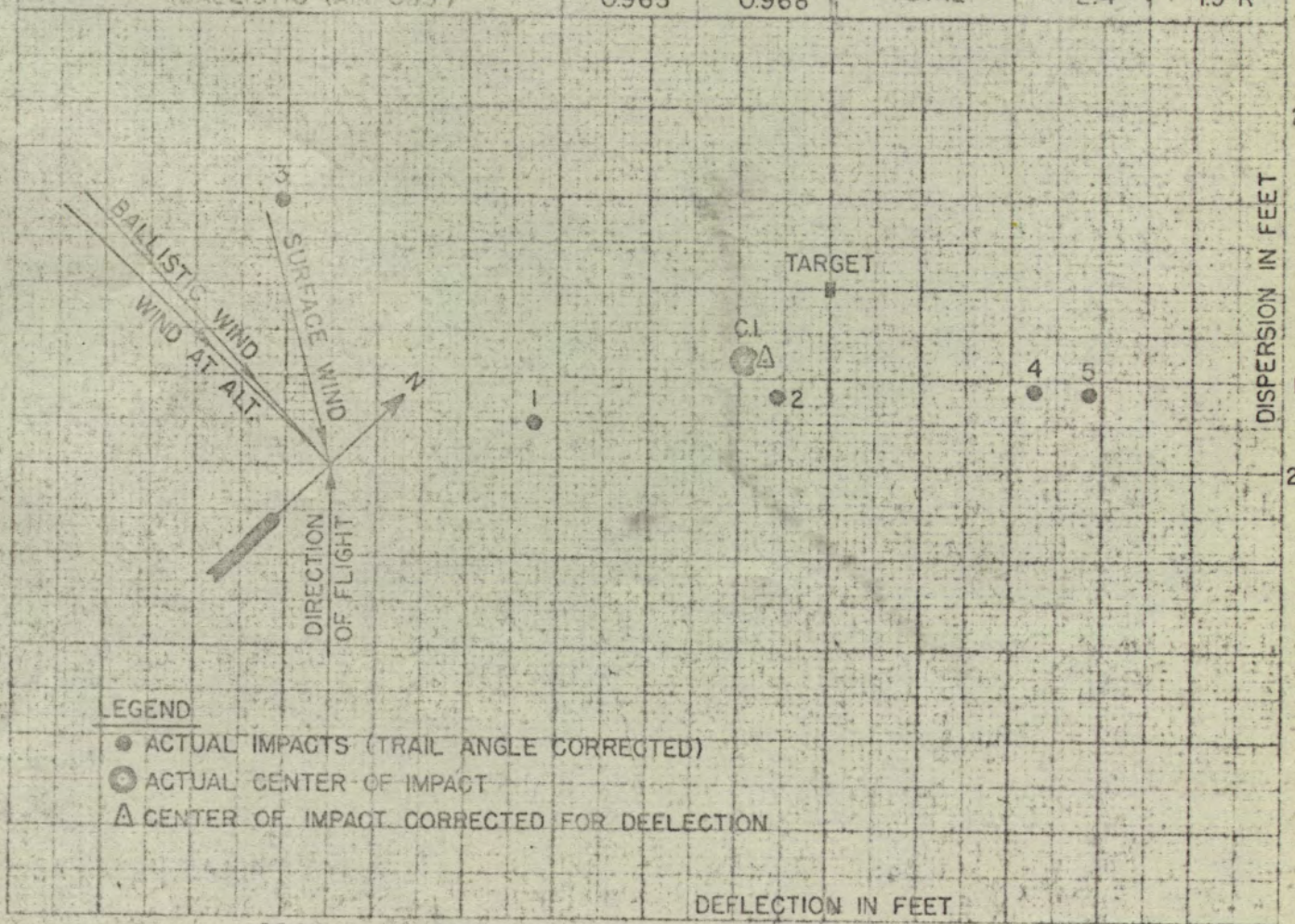
SKY: AIR: TRAIL AND D.S. BASED ON C = 1.60

BOMB NO.	TIME OF REL.	ALTITUDE AIR OBS. FT.	ALTITUDE GRND OBS. FT.	AIR SPEED CAL. IND. M/HR	AIR SPEED TRUE AIR OBS. M/HR	AIR SPEED TRUE GRND. OBS. M/HR	GRND. SPEED GRND. OBS. M/HR	CLIMB-GLIDE AIR OBS. FT/MIN.	CLIMB-GLIDE GRND. OBS. FT/MIN.	DEVIATIONS FROM TARGET RANGE OVER FT.	RANGE SHORT FT.	DEFLECTION RIGHT FT.	DEFLECTION LEFT FT.
1	11:45	12570	12523	134	162.1	160.6	134.4		− 1.8		150		321
2	11:58	12520	12497	132	159.7	154.0	123.4		+ 2.4		120		57
3	12:06	12570	12556	133	161.1	155.4	121.1		+ 44.4	93			603
4	12:14	12540	12508	134	162.1	157.5	126.0		−105.0		111	228	
5	12:25	12520	12489	135	163.4	163.8	133.2		+ 44.4		111	288	
6													
DIFFERENTIAL BALLISTIC WIND M/HR.										CENTER OF IMPACT	80		93
RANGE: −1.7			CROSS: +5.1							MEAN DEVIATION	69		295

	TIME	9:53	1:04
WIND	SURFACE, VELOCITY (M/HR)	17.0	14.0
	AT ALTITUDE, VELOCITY "	35.8	40.4
	BALLISTIC VELOCITY "	31.0	34.1
	BALLISTIC AZIMUTH (TO)	272.0°	284.6°
DENSITY	AT SURFACE	0.968	0.968
	BALLISTIC (SURFACE)	0.989	0.989
	BALLISTIC (AIR OBS.)	0.963	0.968

CORRECTIONS USED

MILS IN	RANGE	DEFL.
WIND	−0.8	1.9 R
DENSITY	−1.6	—
TOTAL	−2.4	1.9 R



RESULTS OF RANGE BOMBING NO. 12

MAY 25, 1938 — 100 LB. PRACTICE BOMB M38A2 — AIRPLANE B18

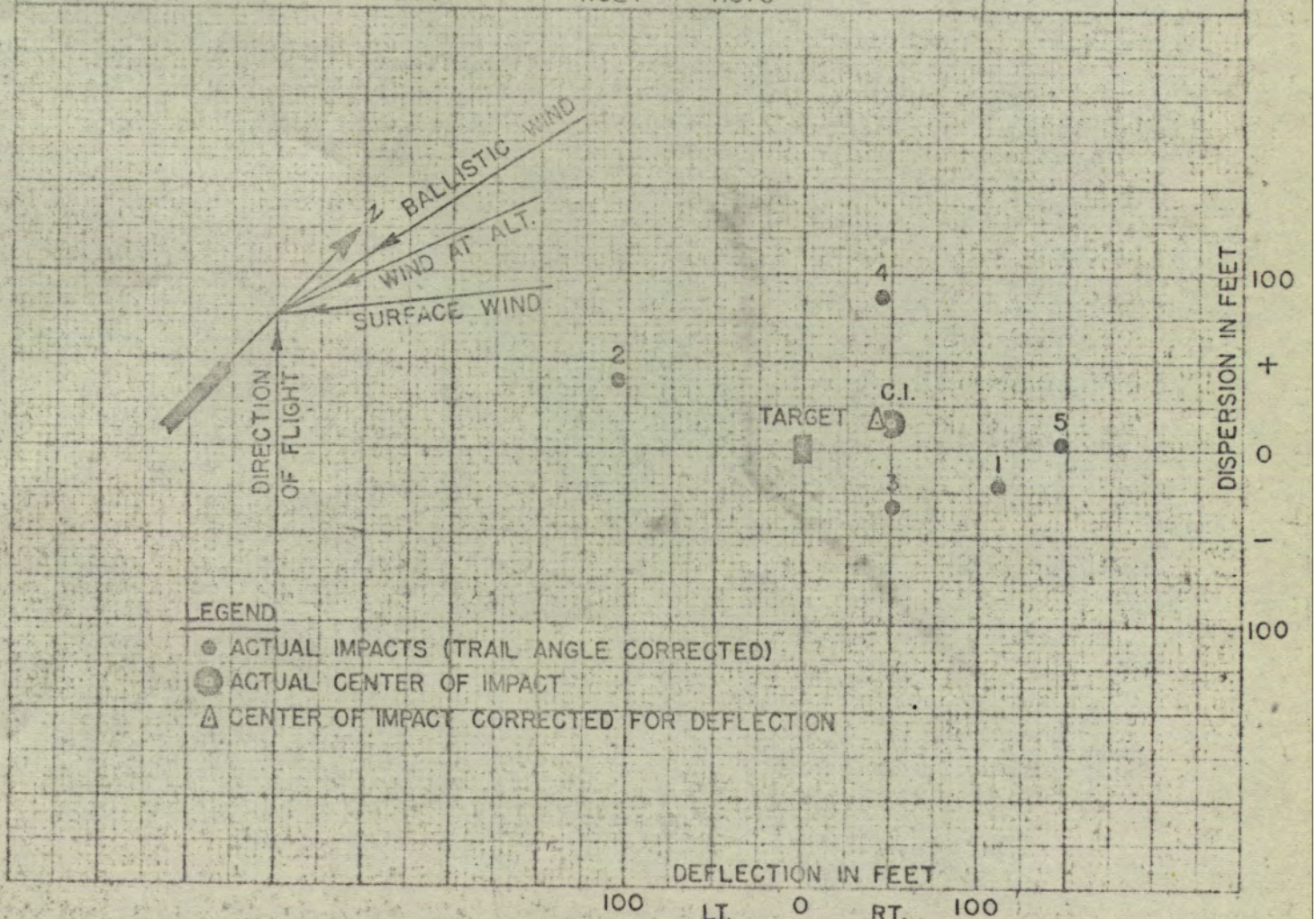
PILOT: W. O. J. A. LEE — BOMBARDIER: CAPT. C. S. THORPE

SKY: — AIR: — TRAIL AND D.S. BASED ON C = 1.60

BOMB NO.	TIME OF REL.	ALTITUDE AIR OBS. FT.	ALTITUDE GR'ND OBS. FT.	AIR SPEED CAL. IND M/HR	AIR SPEED TRUE AIR OBS. M/HR	AIR SPEED TRUE GR'ND OBS. M/HR	GR'ND SPEED GR'ND OBS. M/HR	CLIMB-GLIDE AIR OBS. FT/MIN.	CLIMB-GLIDE GR'ND OBS. FT/MIN.	DEVIATIONS FROM TARGET RANGE OVER FT.	RANGE SHORT FT.	DEFLECTION RIGHT FT.	DEFLECTION LEFT FT.
1	11:36	6180	6176	143	157.2	155.4	155.7		+ 25.8		21	111	
2	11:50	6160	6156	141	154.8	151.5	151.6		+ 6.0	39			105
3	12:02	6160	6167	141	154.8	154.2	154.5		+ 37.8		33	51	
4	12:10	6150	6130	142	155.9	155.0	155.7		- 1.2	87		45	
5	12:15	6110	6057	143	156.7	157.4	158.0		+124.8	3		147	
6													
DIFFERENTIAL BALLISTIC WIND M/HR. — CENTER OF IMPACT										15		50	
RANGE: −1.5 — CROSS: −3.8 — MEAN DEVIATION										38		64	

	TIME	10:32	12:39
WIND	SURFACE, VELOCITY (M/HR)	8.0	6.0
	AT ALTITUDE, VELOCITY "	5.5	3.8
	BALLISTIC VELOCITY "	1.5	1.1
	BALLISTIC AZIMUTH (TO)	12.7°	179.4°
DENSITY	AT SURFACE	1:001	0.992
	BALLISTIC (SURFACE)	1.006	0.999
	BALLISTIC (AIR OBS.)	1.021	1.016

CORRECTIONS USED	MILS IN RANGE	DEFL
WIND	−0.7	1.4 LT.
DENSITY	+2.4	—
TOTAL	+1.7	1.4 LT.



RESULTS OF RANGE BOMBING NO. 37

OCT. 31, 1938 — 100 LB. PRACTICE BOMB — M38 A2 — AIRPLANE B-18

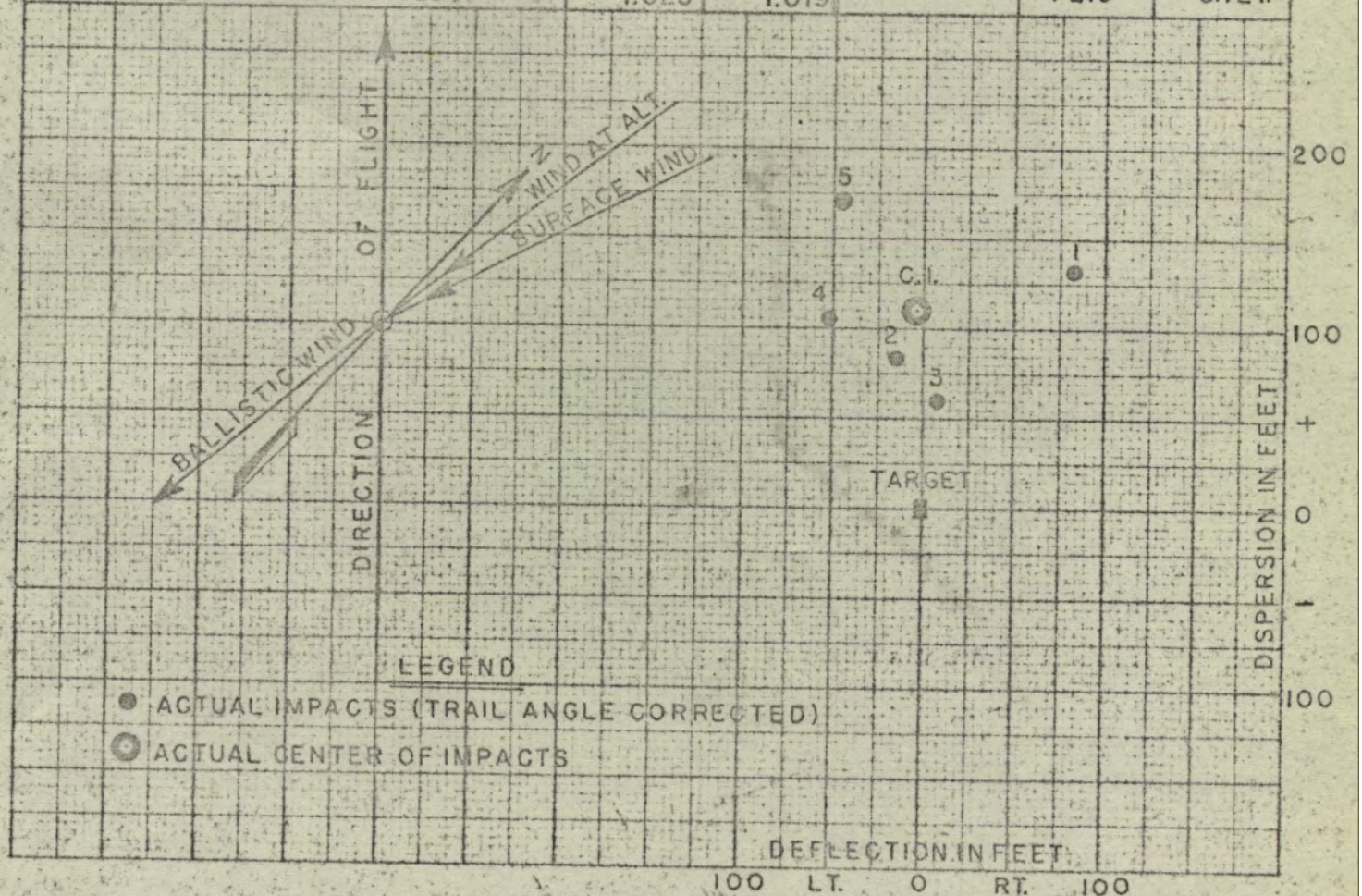
PILOT: CAPT. D.W. WATKINS — BOMBARDIER: CAPT. C.S. THORPE

SKY: — AIR: — TRAIL AND D.S. BASED ON C = 2.019

BOMB NO.	TIME OF REL.	ALTITUDE AIR OBS. FT.	ALTITUDE GR'ND. OBS. FT.	AIR SPEED CAL. IND. M/HR.	AIR SPEED TRUE AIR OBS. M/HR	AIR SPEED TRUE GR'ND. OBS. M/HR.	GR'ND SPEED GR'ND OBS. M/HR.	CLIMB OR GLIDE GR'ND OBS. FT/MIN.	HOR. RANGE FT.	DEVIATIONS FROM TARGET RANGE OVER FT.	RANGE SHORT FT.	DEFLECTION RIGHT FT.	DEFLECTION LEFT FT.
1	10:37	7080	7058	166	185.6	184.5	171.8	- 73.2	4959	132		84	
2	10:45	7090	7069	164	183.4	180.9	168.5	+148.2	4879	84			15
3	10:58	7100	7074	165	184.5	180.3	167.3	- 32.5	4865	60		9	
4	11:07	7040	7035	166	185.5	182.8	171.9	+ 35.8	4978	105			51
5	11:20	7100	7060	165	184.5	180.8	168.0	+ 82 5	4889	171			45
6													
CENTER OF IMPACT										110			4
MEAN DEVIATION										33		40	

TIME		9:22 A.M.	12:52 P.M.
WIND VELOCITY M.P.H.	SURFACE	15.0	7.0
	AT ALTITUDE, BALLISTIC	20.3	16.8
	DIFFERENTIAL BALLISTIC — RANGE	20.7	16.3
	DIFFERENTIAL BALLISTIC — RANGE	+1.0	-0.6
	DIFFERENTIAL BALLISTIC — CROSS	-0.3	-0.1
DENSITY	AT SURFACE	1.050	1.031
	BALLISTIC (SURFACE)	1.044	1.029
	BALLISTIC (AIR OBS.)	1.023	1.019

CORRECTIONS USED	MILS IN RANGE	DEFL.
WIND	+0.4	0.1 LT.
DENSITY	+2.5	——
TOTAL	+2.9	0.1 LT.



RESULTS OF RANGE BOMBING NO. 38

OCT. 31, 1938 — 100 LB. PRACTICE BOMB — M38A2 — AIRPLANE B-4A

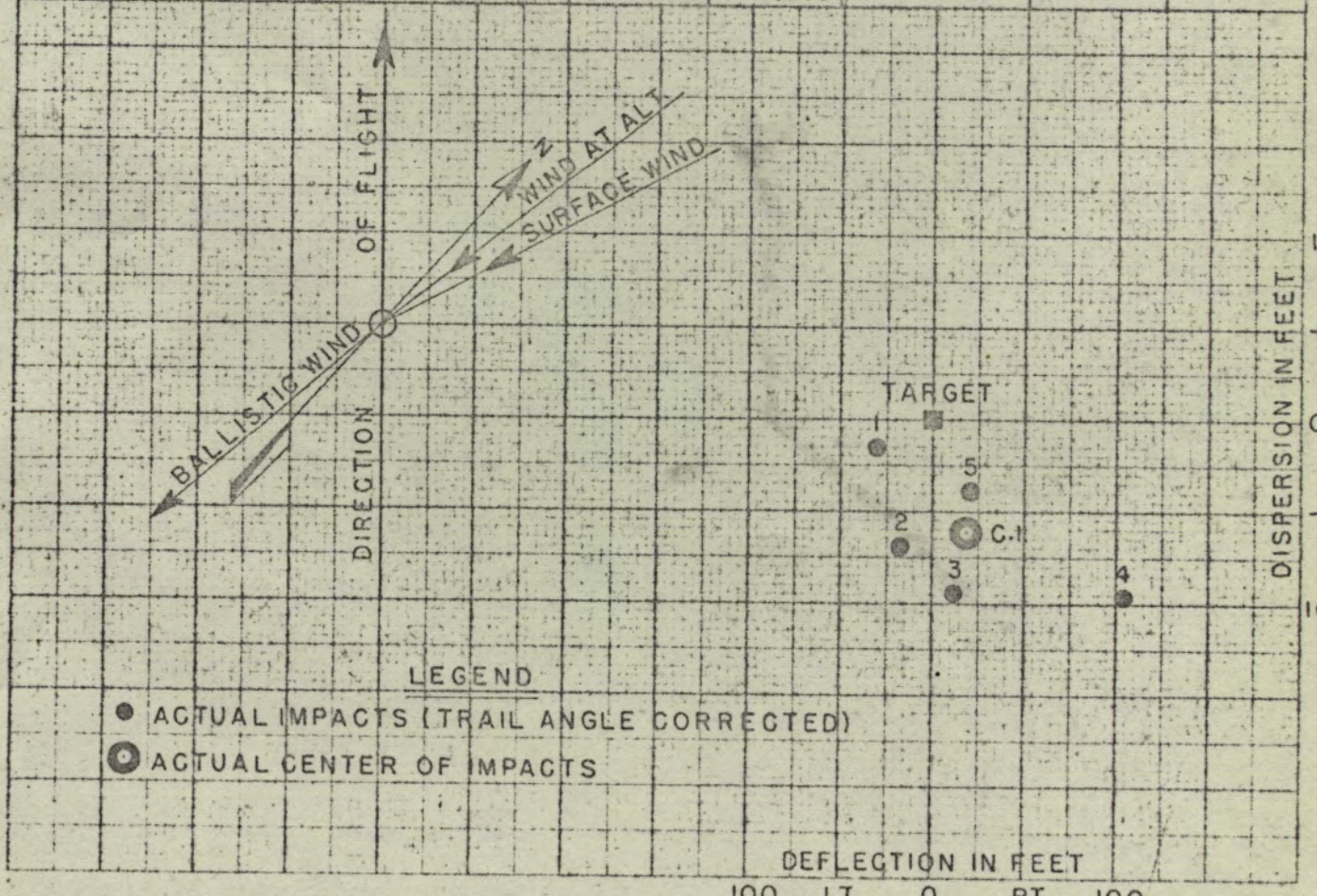
PILOT: W.O. J.A. LEE — BOMBARDIER: SGT. S.C. SMINK

SKY: — AIR: — TRAIL AND D.S. BASED ON C = 2.019

BOMB NO.	TIME OF REL.	ALTITUDE AIR OBS. FT.	ALTITUDE GR'ND OBS. FT.	AIR SPEED IND. M/HR.	AIR SPEED TRUE AIR OBS. M/HR.	AIR SPEED TRUE GR'ND OBS. M/HR.	GR'ND SPEED GR'ND OBS. M/HR.	CLIMB OR GLIDE GR'ND OBS. FT/MIN.	HOR. RANGE FT.	DEVIATIONS FROM TARGET: RANGE OVER FT.	RANGE SHORT FT.	DEFLECTION RIGHT FT.	DEFLECTION LEFT FT.
1	10:53	7120	6970	79	88.2	88.5	74.7	+ 87.7	2183		15		30
2	11:03	7200	6989	82	91.6	90.5	76.6	+ 46.8	2258		69		18
3	11:18	7180	6926	78	87.0	88.6	76.0	- 37.9	2230		93	12	
4	11:26	7120	6922	80	89.2	87.4	73.5	-271.8	2197		96	105	
5	11:33	7080	6907	82	91.5	90.2	77.4	0	2259		39	21	
6													
CENTER OF IMPACT											62.	18	
MEAN DEVIATION										28		36	

TIME		9:22 A.M.	12:52 P.M.
WIND VELOCITY M.P.H. — SURFACE		15.0	7.0
WIND VELOCITY M.P.H. — AT ALTITUDE		20.3	16.8
WIND VELOCITY M.P.H. — BALLISTIC		20.7	16.0
WIND VELOCITY M.P.H. — DIFFERENTIAL BALLISTIC	RANGE	+1.0	-0.7
WIND VELOCITY M.P.H. — DIFFERENTIAL BALLISTIC	CROSS	-0.3	-0.4
DENSITY — AT SURFACE		1.050	1.031
DENSITY — BALLISTIC (SURFACE)		1.044	1.029
DENSITY — BALLISTIC (AIR OBS.)		1.023	1.019

CORRECTIONS USED	MILS IN RANGE	MILS IN DEFL.
WIND	+0.3	0.1 LT.
DENSITY	+2.5	——
TOTAL	+2.8	0.1 LT.



RESULTS OF RANGE BOMBING NO. 45

NOV. 10, 1938 — 100 LB. PRACTICE BOMB — M38A2 — AIRPLANE B-18

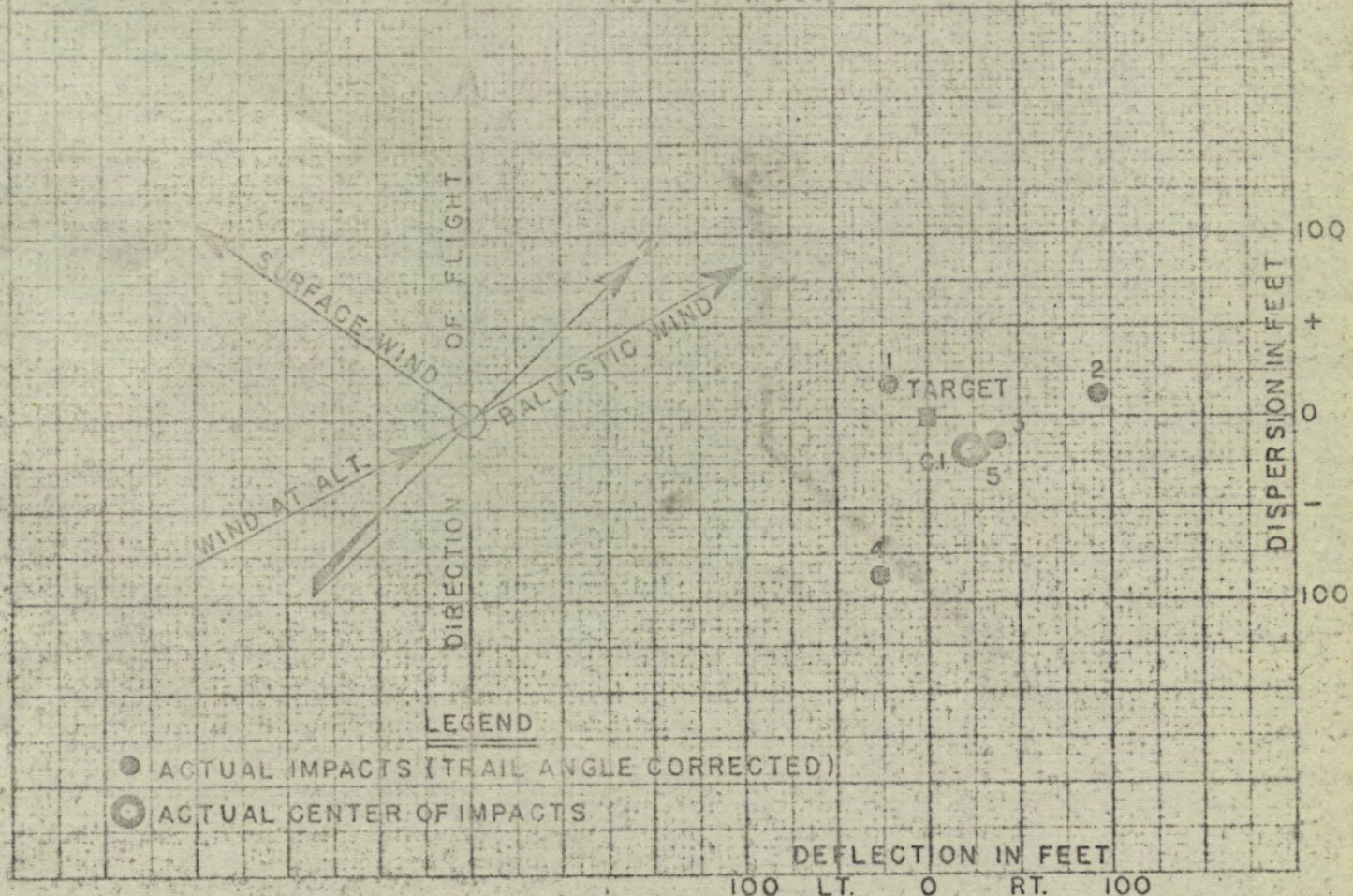
PILOT: CAPT. D.W. WATKINS — BOMBARDIER: CAPT. C.S. THORPE

SKY: — AIR: — TRAIL AND D.S. BASED ON C = 2.019

BOMB NO.	TIME OF REL.	ALTITUDE		AIR SPEED			GR'ND SPEED	CLIMB OR GLIDE	HOR. RANGE	DEVIATIONS FROM TARGET			
		AIR OBS.	GR'ND OBS.	CAL. IND.	TRUE AIR C.S.	TRUE GR'ND. OBS.	GR'ND OBS.	GR'ND OBS.		RANGE		DEFLECTION	
		FT.	FT.	M/HR.	M/HR.	M/HR.	M/HR.	FT/MIN.	FT.	OVER FT.	SHORT FT.	RIGHT FT.	LEFT FT.
1	11:21	7140	7138	165	184.7	181.2	186.0	+233.3	5524	18			21
2	11:29	7120	7112	164	183.5	181.6	186.8	+ 15.7	5479	12		93	
3	11:46	7140	7137	165	184.7	182.9	187.1	- 20.0	5512		12	36	
4	11:53	7140	7134	165	184.7	183.5	187.3	+ 74.6	5490		87		27
5	12:00	7140	7136	165	184.7	182.6	187.0	+150.0	5511		18	27	
6													
CENTER OF IMPACT											17	22	
MEAN DEVIATION										28		36	

		TIME	10:50	1:14
WIND VELOCITY M.P.H.	SURFACE		5.0	5.0
	AT ALTITUDE		16.4	23.7
	DIFFERENTIAL BALLISTIC	RANGE	14.0	19.9
			+1.1	-0.1
		CROSS	+2.1	+3.9
DENSITY	AT SURFACE		1.044	1.030
	ALT.	(SURFACE)	1.039	1.025
			1.018	1.008

CORRECTIONS USED		
MILS IN	RANGE	DEFL.
WIND	+0.4	0.7 RT.
DENSITY	+2.2	——
TOTAL	+2.6	0.7 RT.



RESULTS OF RANGE BOMBING NO. 46

NOV. 10, 1938 — 100 LB. PRACTICE BOMB — M38A2 — AIRPLANE B-4A

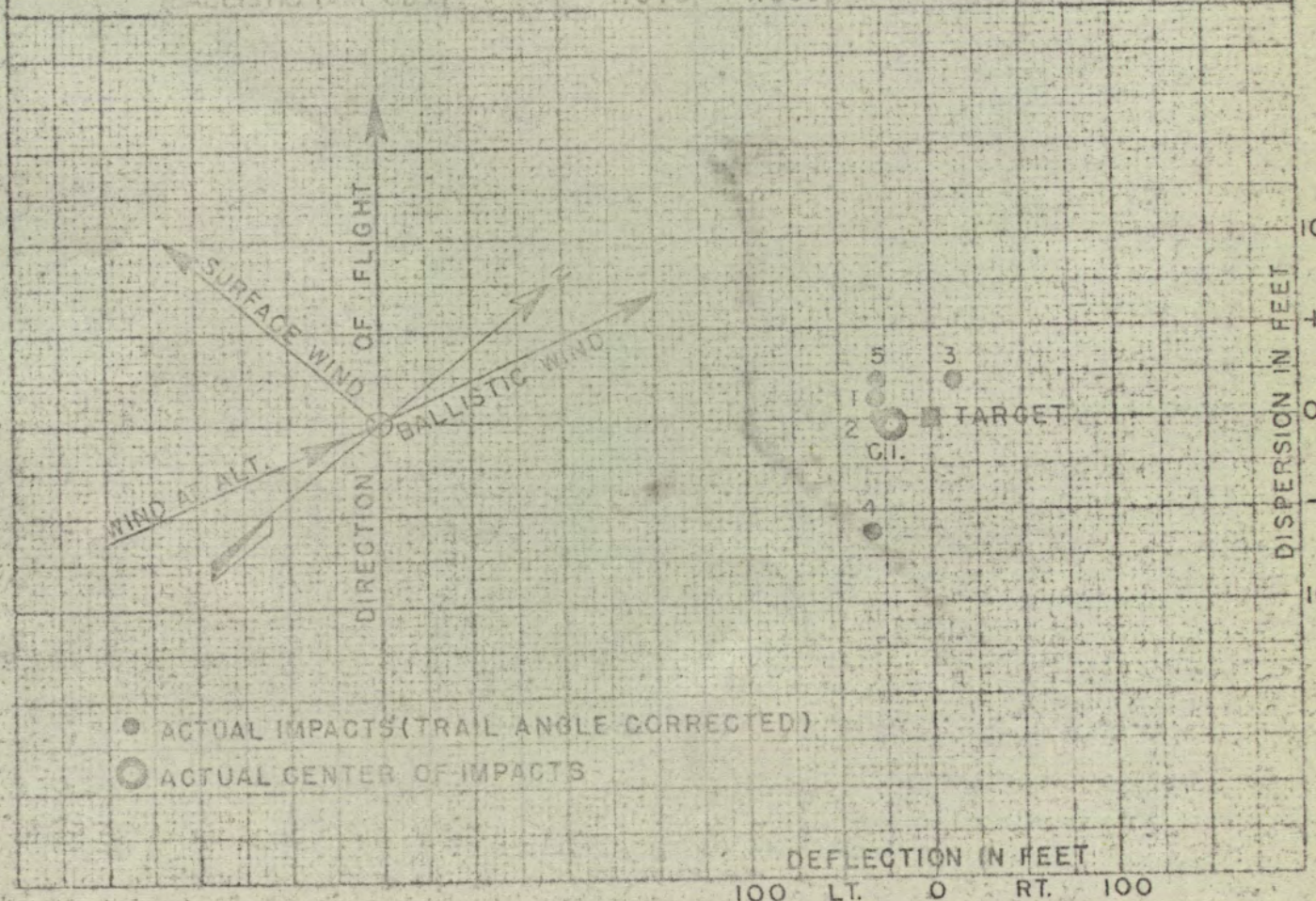
PILOT: W.O. J.A. LEE — BOMBARDIER SGT. S.C. SMINK

SKY: AIR: — TRAIL AND D.S. BASED ON C = 2.019

BOMB NO.	TIME OF REL.	ALTITUDE AIR OBS. FT	ALTITUDE GR'ND. OBS. FT.	AIR SPEED IND. M/HR.	AIR SPEED TRUE AIR OBS. M/HR.	AIR SPEED TRUE GR'ND. OBS. M/HR.	GR'ND SPEED GR'ND OBS. M/HR.	CLIMB OR GLIDE GR'ND OBS. FT/MIN.	HOR. RANGE FT.	DEVIATIONS FROM TARGET RANGE OVER FT.	RANGE SHORT FT.	DEFLECTION RIGHT FT.	DEFLECTION LEFT FT.
1	11:25	7130	7144	85	95.1	95.0	96.4	+ 38.4	2885	12			30
2	11:32	7130	7092	85	95.1	95.6	98.0	+ 15.8	2886	0	0		27
3	11:38	7130	7138	85	95.1	97.2	99.7	+ 32.2	2967	21		12	
4	11:49	7130	7133	85	95.1	94.2	96.5	+ 78.4	2873		63		33
5	11:56	7130	7086	85	95.1	98.5	100.8	+ 5.2	2993	21			27
6													
CENTER OF IMPACT											2		21
MEAN DEVIATION										25		13	

		TIME	10:50	1:14
WIND VELOCITY M.P.H.	SURFACE		5.0	5.0
	AT ALTITUDE		16.4	23.7
	BALLISTIC		13.3	18.5
	DIFFERENTIAL BALLISTIC	RANGE	+1.3	−0.4
		CROSS	+2.8	+5.3
DENSITY	AT SURFACE		1.044	1.030
	BALLISTIC (SURFACE)		1.039	1.025
	BALLISTIC (AIR OBS.)		1.018	1.008

CORRECTIONS USED		
MILS IN	RANGE	DEFL.
WIND	+ 0.3	0.7 RT.
DENSITY	+ 2.2	——
TOTAL	+ 2.5	0.7 RT.



RESULTS OF RANGE BOMBING NO. 49

JULY 11, 1939 — 100 LB. PRACTICE BOMB M38A2 — AIRPLANE B18A

PILOT: CAPT. D.W. WATKINS — BOMBARDIER: CAPT. C.S. THORPE

SKY: — AIR: — TRAIL AND D.S. BASED ON C = 1.21

BOMB NO.	TIME OF REL.	ALTITUDE		AIR SPEED			GR'ND SPEED	CLIMB OR GLIDE	HOR. RANGE	DEVIATIONS FROM TARGET			
		AIR	GR'ND.	CAL.	TRUE		GR'ND	GR'ND		RANGE		DEFLECTION	
		OBS.	OBS.	IND.	AIR OBS.	GR'ND. OBS.	OBS.	OBS.		OVER	SHORT	RIGHT	LEFT
		FT.	FT.	M/HR.	M/HR.	M/HR.	M/HR.	FT/MIN.	FT.	FT.	FT.	FT.	FT.
1	10:38	19850	19496	125	170.1	161.9	121.8	+124.1	5538	543		42	
2	10:48	19850	19452	124	168.5	162.1	126.5	+148.5	5774	384		57	
3	10:57	19850	19547	125	171.1	165.2	131.0	- 23.6	5996	153		177	
4	11:12	19850	19451	126	171.2	161.5	126.2	+114.1	5819	366			291
5	11:23	19870	19478	121	164.5	156.1	121.6	- 33.1	5530	201			300
6	11:32	19830	19414	126	171.1	164.5	131.2	- 74.5	6035	519		12	
CENTER OF IMPACT													
MEAN DEVIATION													

TIME		
WIND VELOCITY M.P.H. — SURFACE		
WIND VELOCITY M.P.H. — AT ALTITUDE		
WIND VELOCITY M.P.H. — BALLISTIC		
WIND VELOCITY M.P.H. — DIFFERENTIAL BALLISTIC — RANGE		
WIND VELOCITY M.P.H. — DIFFERENTIAL BALLISTIC — CROSS		
DENSITY — AT SURFACE		
DENSITY — BALLISTIC (SURFACE)		
DENSITY — BALLISTIC (AIR OBS.)		

CORRECTIONS USED		
MILS IN	RANGE	DEFL.
WIND		
DENSITY		
TOTAL		

NOTE - SEE PLOT NO. 49A FOR CORRECTIONS AND PLOT OF BOMBS.

RESULTS OF RANGE BOMBING NO. 49A.

JULY 11, 1939. 100 LB. PRACTICE BOMB M38A2 AIRPLANE B18A

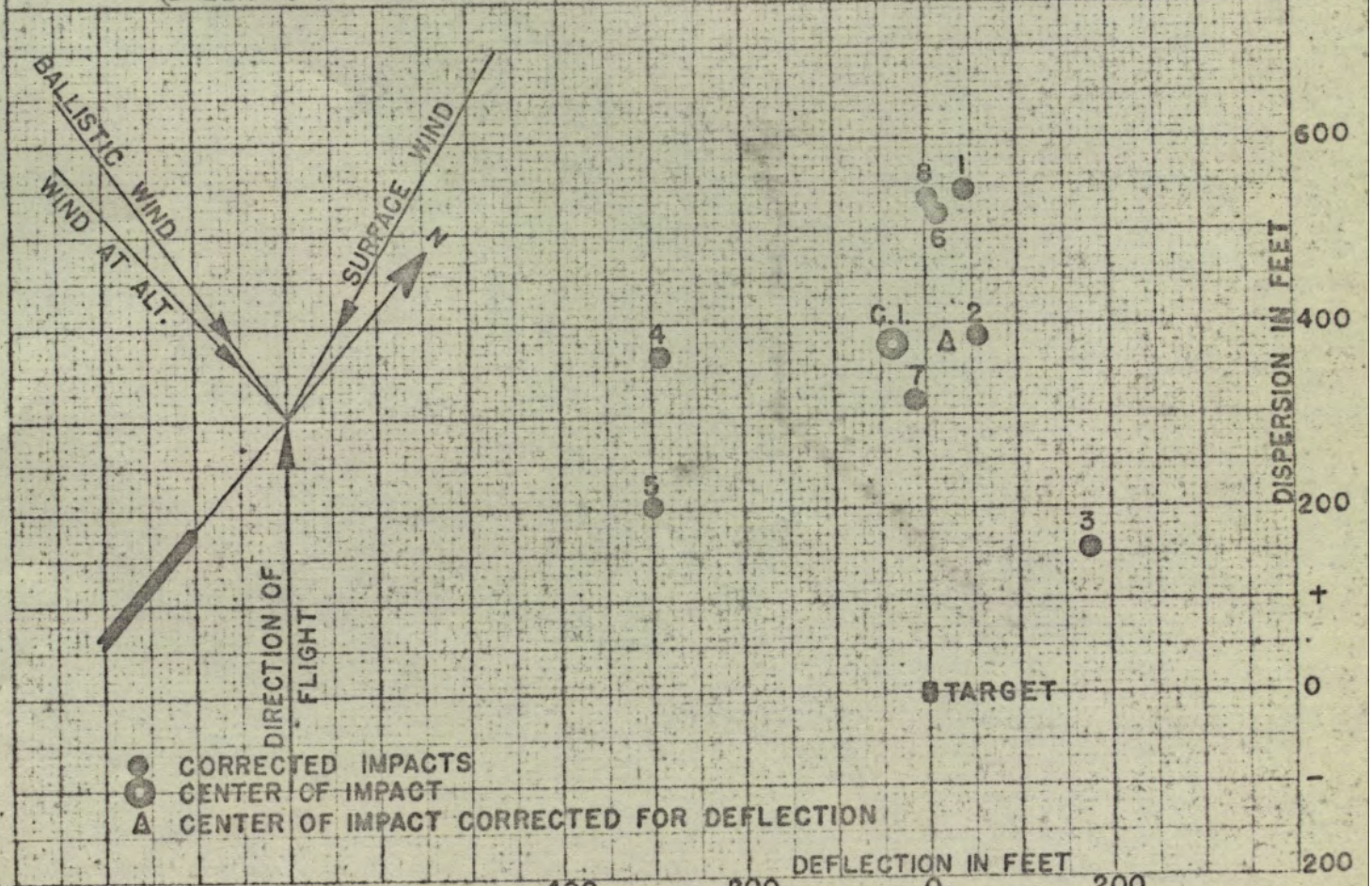
PILOT: CAPT. D.W. WATKINS BOMBARDIER: CAPT. C.S. THORPE

SKY: AIR: TRAIL AND D.S. BASED ON C=1.21

BOMB NO.	TIME OF REL.	ALTITUDE		AIR SPEED			GR'ND SPEED	CLIMB OR GLIDE	HOR. RANGE	DEVIATIONS FROM TARGET			
					TRUE					RANGE		DEFLECTION	
		AIR OBS. FT.	GR'ND OBS. FT.	CAL. IND. M/HR.	AIR OBS. M/HR.	GR'ND OBS. M/HR.	GR'ND OBS. M/HR.	GR'ND OBS. FT/MIN	FT.	OVER FT.	SHORT FT.	RIGHT FT.	LEFT FT.
7	11:41	19850	19429	123	167.1	160.5	129.4	+ 32.9	5858	315			12
8	11:53	19850	19426	124	168.4	163.6	126.8	- 36.3	5830	534		3	
3													
4													
5													
6													
CENTER OF IMPACT										377			39
MEAN DEVIATION										118			128

		TIME	9:54	12:36
WIND VELOCITY M.P.H.	SURFACE		11.0	9.0
	AT ALTITUDE		39.3	47.7
	BALLISTIC		32.8	34.3
	DIFFERENTIAL BALLISTIC	RANGE	-3.1	-12.3
		CROSS	+7.0	+ 5.4
DENSITY	AT SURFACE		0.996	0.988
	BALLISTIC (SURFACE)		1.007	1.002
	BALLISTIC (AIR OBS.)		0.954	

CORRECTIONS USED		
MILS IN	RANGE	DEFL.
WIND	-1.6	3.1 R
DENSITY	-0.2	—
TOTAL	-1.8	3.1 R



RESULTS OF RANGE BOMBING NO. 50

JULY 17, 1939. BOMBS NO. 1 & 2 100 LB. PRACTICE M38A2 AIRPLANE B18A
BOMBS NO. 3-7 100 LB. DEMOLITION M30
PILOT: CAPT. D.W. WATKINS & W.O. J.A. LEE BOMBARDIER: SGT. S.C. SMINK

SKY: AIR: TRAIL AND D.S. BASED ON C=1.21

BOMB NO.	TIME OF REL.	ALTITUDE		AIR SPEED			GR'ND SPEED	CLIMB OR GLIDE	HOR. RANGE	DEVIATIONS FROM TARGET			
										RANGE		DEFLECTION	
		AIR OBS.	GR'ND OBS.	CAL. IND.	TRUE AIR OBS.	TRUE GR'ND OBS.	GR'ND OBS.	GR'ND OBS.		OVER	SHORT	RIGHT	LEFT
		FT.	FT.	M/HR.	M/HR.	M/HR.	M/HR.	FT/MIN.	FT.	FT.	FT.	FT.	FT.
1	10:35	19900	19574	121	164.8	160.0	122.4	+204.9	5642	267		303	
2	10:45	19900	19609	119	162.2	157.1	118.1	- 31.6	5350	282			384
3	10:53	19900	19564	120	163.4	161.0	122.0	- 97.7	5181		390	3	
4	11:00	19900	19556	123	167.5	166.0	125.5	- 59.0	5492	45			60
5	11:09	19900	19575	122	166.2	165.0	124.2	- 75.5	5504	87		327	
6	11:15	19900	19559	121	164.8	164.9	124.8	+ 65.9	5485	264		12	
									CENTER OF IMPACT				
									MEAN DEVIATION				

TIME			CORRECTIONS USED		
			MILS IN	RANGE	DEFL.
WIND VELOCITY M.P.H. { SURFACE; AT ALTITUDE; BALLISTIC; DIFFERENTIAL BALLISTIC { RANGE; CROSS } }			WIND		
DENSITY { AT SURFACE; BALLISTIC (SURFACE); BALLISTIC (AIR OBS.) }			DENSITY		
			TOTAL		

NOTE - SEE PLOT NO. 50A FOR CORRECTIONS AND PLOT OF BOMBS.

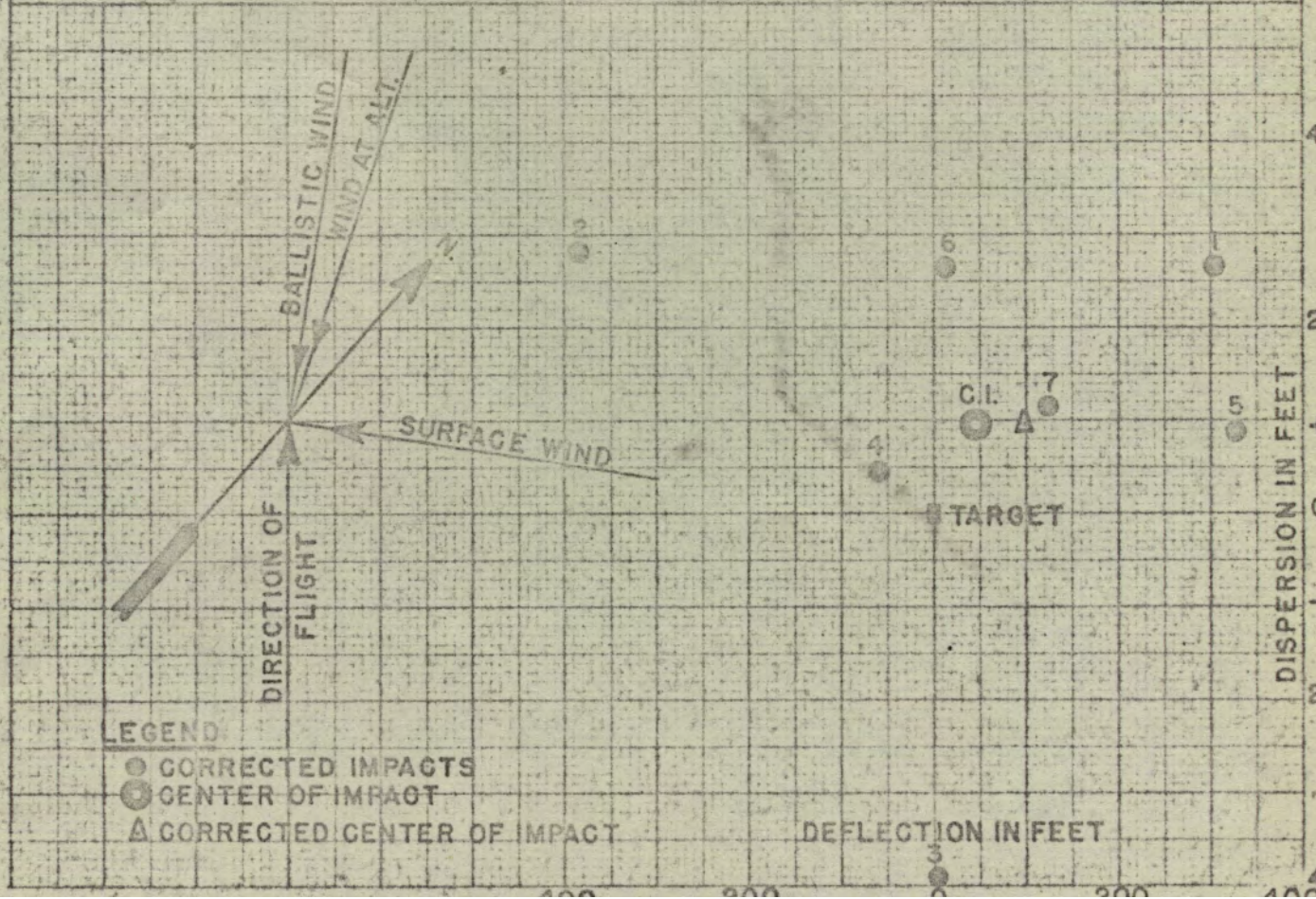
RESULTS OF RANGE BOMBING NO.50A

JULY 17, 1939. BOMBS NO.1&2 100 LB. PRACTICE M38A2 AIRPLANE B18A
BOMBS NO.3-7 100 LB. DEMOLITION M30
PILOT: CAPT. D.W. WATKINS & W.O. J.A. LEE BOMBARDIER: SGT. S.C. SMINK
SKY: AIR: TRAIL AND D.S. BASED ON C = 1.21

BOMB NO.	TIME OF REL.	ALTITUDE AIR OBS. FT.	ALTITUDE GR'ND OBS. FT.	AIR SPEED CAL. IND. M/HR.	AIR SPEED TRUE AIR OBS. M/HR.	AIR SPEED TRUE GR'ND OBS. M/HR.	GR'ND SPEED GR'ND OBS. M/HR.	CLIMB OR GLIDE GR'ND OBS. FT/MIN.	HOR. RANGE FT.	DEVIATIONS FROM TARGET RANGE OVER FT.	RANGE SHORT FT.	DEFLECTION RIGHT FT.	DEFLECTION LEFT FT.
7	11:28	19910	19575	123	167.6	165.1	125.5	+ 7.0	5585	114		123	
2													
3													
4													
5													
6													
CENTER OF IMPACT										96		46	
MEAN DEVIATION										156		175	

		TIME	10:00	11:55
WIND VELOCITY M.P.H.	SURFACE		4.0	6.0
	AT ALTITUDE		38.7	42.0
	BALLISTIC		31.5	32.1
	DIFFERENTIAL BALLISTIC	RANGE	- 6.0	- 5.8
		CROSS	-10.2	+ 0.2
DENSITY	AT SURFACE		0.991	0.983
	BALLISTIC (SURFACE)		1.005	1.001
	BALLISTIC (AIR OBS.)		0.948	

CORRECTIONS USED MILS IN	RANGE	DEFL.
WIND	-3.1	2.6 L
DENSITY	-0.5	—
TOTAL	-3.6	2.6 L



RESULTS OF RANGE BOMBING NO. 61

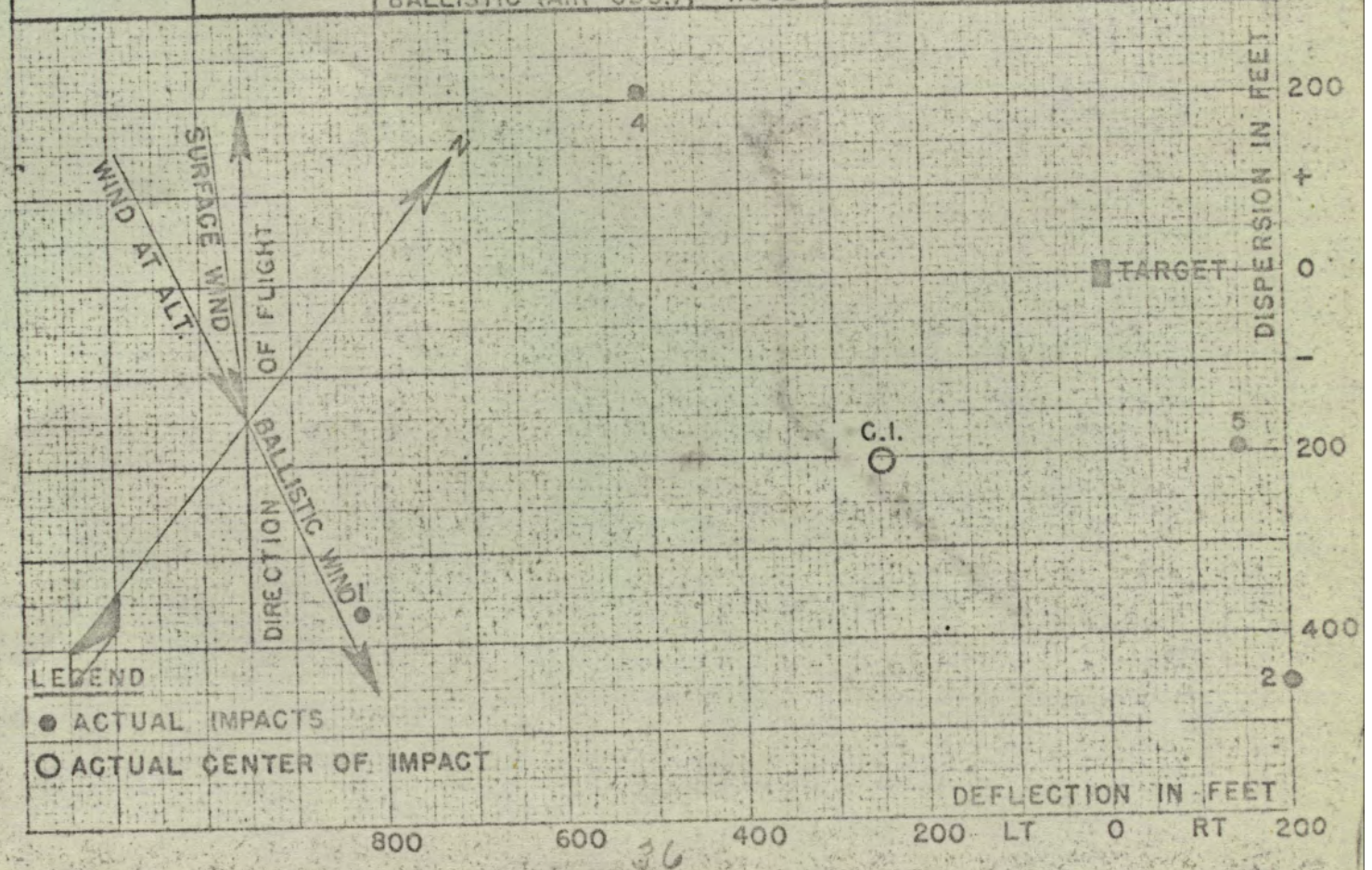
JUNE 21, 1940 100 LB PRACTICE BOMB M38A2 AIRPLANE B-17B

PILOT: LT. B.A. SCHREIRER BOMBARDIER: LT. M.F. SUMMERFELT

SKY: CLEAR AIR: SMOOTH TRAIL AND D.S. BASED ON BT-100-B-2

BOMB NO.	TIME OF REL.	ALTITUDE		AIR SPEED			GR'ND SPEED	CLIMB OR GLIDE	HOR. RANGE	DEVIATIONS FROM TARGET			
										RANGE		DEFLECTION	
		AIR OBS FT.	GR'ND OBS FT.	CAL IND M/HR	TRUE AIR OBS. M/HR	TRUE GR'ND OBS. M/HR	GR'ND OBS. M/HR	GR'ND OBS. FT/MIN	FT.	OVER FT.	SHORT FT.	RIGHT FT.	LEFT FT.
1	6:29	25180	24264	160	234.7	224.7	178.5	-320.7	8720		366		828
2	6:37	25130	24346	158	232.1	217.5	171.7	-154.0	8347		456	201	
3		24990		158									
4	6:55	25210	24366	157	230.7	221.1	174.3	-152.6	8349	207			513
5	7:03	25250	24372	158	232.2	222.0	176.8	-4203	8724		195	147	
6													
CENTER OF IMPACT											203		248
MEAN DEVIATION										209		422	

		R.O.S.	R.O.S.	CAMERA
TIME		5:30	7:23	7:03
WIND VELOCITY M.P.H.	SURFACE		11.0	15.0
	AT ALTITUDE		50.4	
	BALLISTIC RANGE WIND		-41.6	
	BALLISTIC CROSS WIND		18.5	
DENSITY	AT SURFACE	0.999		1.007
	BALLISTIC (SURFACE)	1.011		1.013
	BALLISTIC (AIR OBS.)	1.033		



RESULTS OF RANGE BOMBING NO. 65

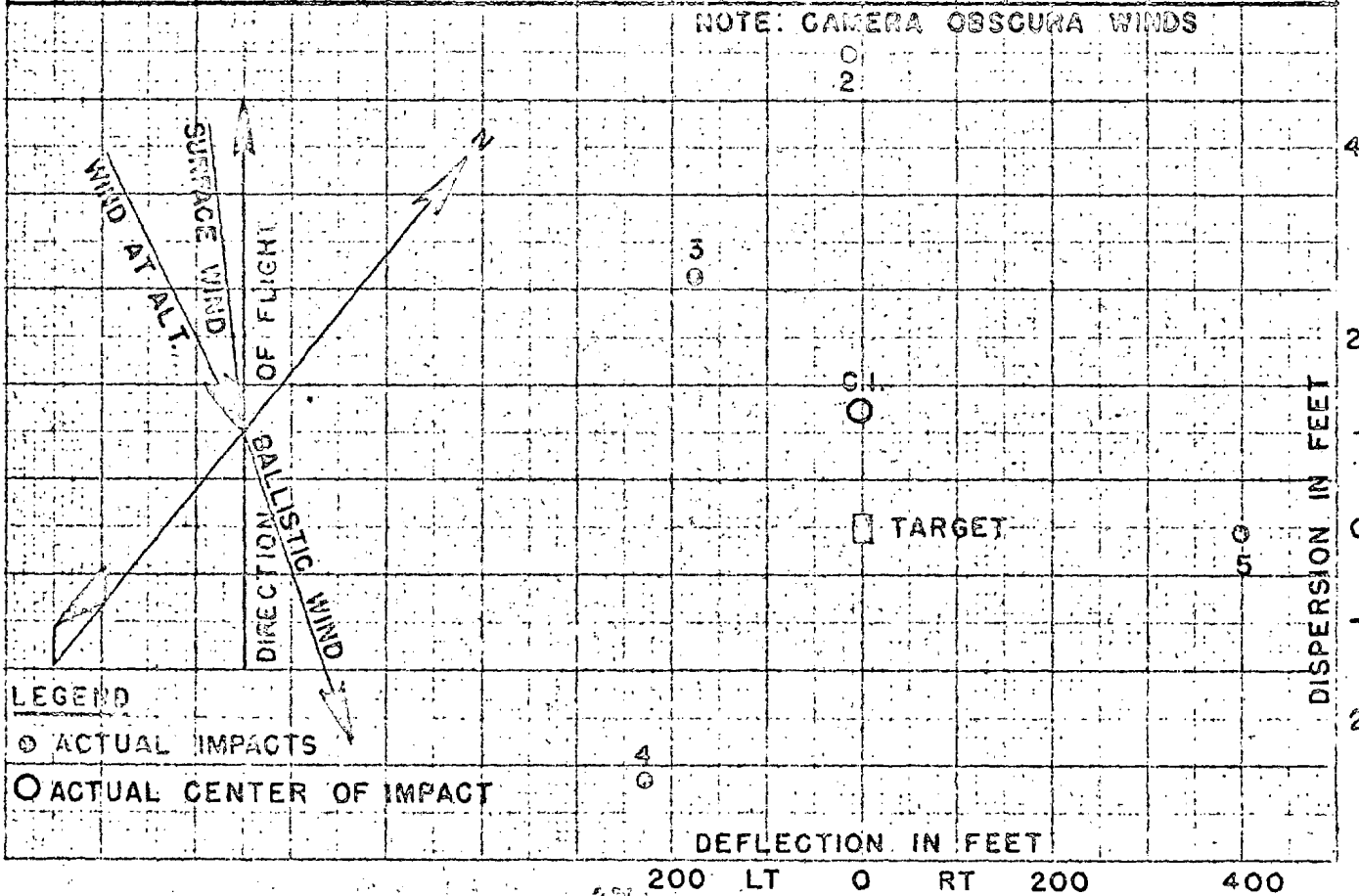
JULY 5, 1940 — 100 LB PRACTICE BOMB M38A2 — AIRPLANE B-17B

PILOT: LT. C.A. PETERSON — BOMBARDIER: LIEUT. M.F. SUMMERFELT

SKY: CLEAR — AIR: — TRAIL AND D.S. BASED ON BT-100-B-2

BOMB NO.	TIME OF REL.	ALTITUDE		AIR SPEED			GR'ND SPEED	CLIMB OR GLIDE	HOR. RANGE	DEVIATIONS FROM TARGET			
										RANGE		DEFLECTION	
		AIR OBS. FT.	GR'ND OBS. FT.	CAL IND M/HR	TRUE AIR OBS. M/HR	TRUE GR'ND OBS. M/HR	GR'ND OBS. M/HR	GR'ND OBS. FT/MIN	FT.	OVER FT.	SHORT FT.	RIGHT FT.	LEFT FT.
1	LOST	25430		163									
2	9:46	25430	24853	163	241.3	240.1	158.3	+189.8	7956	498			15
3	9:58	25430	24760	163	241.0	240.4	153.6	-135.3	7757	264			177
4	10:09	25430	24755	164	242.4	241.4	160.8	-157.3	7806		267		228
5	10:30	25430	24777	165	244.0	243.0	162.7	+114.6	7889		6	399	
6													
CENTER OF IMPACT										122			5
MEAN DEVIATION										259		202	

		R.O.S.	R.O.S.	CAMERA
TIME		9:25		10:40
WIND VELOCITY M.P.H.	SURFACE			8.0
	AT ALTITUDE			36.3
	BALLISTIC RANGE WIND			-59.4
	BALLISTIC CROSS WIND			20.2
DENSITY	AT SURFACE			0.998
	BALLISTIC (SURFACE)			1.010
	BALLISTIC (AIR OBS.)	1.003		



Appendix C

Individual Standard Elements and Ballistic Coefficients from Reduction of Field Data

Appendix C

Program, Group, Serial Number	Date of Release, Run No.	Y Standard Altitude ft.	U Standard True Air Speed mi./hr.	X Standard Range ft.	T Standard Time of Flight sec.	λ Standard Trail ft.	C_X	C_T	C_λ
KS-138L-8	3/9/38-1	9000	160	5284			1.81		
9	2			5277			1.76		
12	3			5302			1.94		
10	4			5197	25.19	714	1.36	1.00	1.18
11	5			5214	25.07	669	1.43	1.09	1.26
7	6			5287	25.03	587	1.83	1.12	1.45
KS-138-13	3/21/38-1			5256	24.71	543	1.64	1.48	1.57
18	2			5243	24.74	563	1.57	1.45	1.51
14	3			5293			1.87		
17	4			5251	24.80	569	1.61	1.37	1.50
16	6			5214	24.59	556	1.43	1.69	1.53
19	4/25/38-1	12000		5925			1.28		
20	2			5956			1.37		
22	4			5977			1.44		
23	5			5971			1.42		
24	4/28/38-1	6000		4374	20.06	335	2.07	1.29	1.65
26	3			4363	20.10	352	1.94	1.24	1.56
31	4			4331	20.01	365	1.62	1.39	1.51
27	5			4305	19.96	380	1.43	1.50	1.46
32	6			4365	20.10	352	1.96	1.23	1.57
28	5/2/38-1	15000	160	6651	32.52	980	1.47	1.42	1.45
36	2			6637	32.62	1017	1.43	1.35	1.39
33	3			6582	32.80	1114	1.29	1.24	1.26
37	4			6530	33.01	1217	1.18	1.13	1.16
34	5			6637	32.78	1055	1.43	1.25	1.34

Appendix C (Cont'd)

Program, Group, Serial Number	Date of Release, Run No.	Y Standard Altitude ft.	U Standard True Air Speed mi./hr.	X Standard Range ft.	T Standard Time of Flight sec.	λ Standard Trail ft.	C_X	C_T	C_λ
KS-138-38	5/3/38--1	15000	160	6637	32.87	1077	1.43	1.20	1.31
39	2			6758	32.62	896	1.87	1.35	1.59
40	3			6541	32.49	1084	1.20	1.44	1.30
41	4			6677	32.82	1024	1.55	1.23	1.38
42	5			6550	32.59	1097	1.22	1.37	1.28
43	6			6651	32.71	1026	1.47	1.29	1.38
35	5/6/38--1	12000		5959	29.11	873	1.38	1.20	1.29
48	2			6014	29.03	798	1.58	1.26	1.42
44	3			6055	28.99	747	1.77	1.29	1.52
49	4			5974	29.04	841	1.43	1.25	1.34
46	5			5986	29.13	850	1.47	1.19	1.33
53	5/25/38-1	6000		4297	19.89	371	1.38	1.68	1.49
54	2			4372	20.27	384	2.05	1.01	1.44
55	3			4346	19.98	344	1.75	1.45	1.60
52	4			4379	20.06	330	2.14	1.29	1.68
51	5			4336	20.00	357	1.66	1.42	1.55
RX-138-107	10/31/38-1	7000	180	5239	21.69	487	1.69	1.46	1.58
112	-2			5223	21.57	471	1.59	1.71	1.64
109	3			5260	21.68	464	1.84	1.48	1.66
110	4			5241	21.60	461	1.70	1.63	1.67
111	5			5245	21.61	460	1.73	1.61	1.68
102	1		90	2664	21.31	149	1.87	2.28	2.05
103	2			2681	21.34	136	2.32	2.15	2.25
104	3			2682	21.64	174	2.35	1.35	1.76
105	4			2727	21.77	147	6.19	1.16	2.08

Appendix C (Cont'd)

Program, Group, Serial Number	Date of Release, Run No,	Y Standard Altitude ft.	U Standard True Air Speed mi./hr.	X Standard Range ft.	T Standard Time of Flight sec.	λ Standard Trail ft.	C_X	C_T	C_λ
RX-138-106	10/31/38-5	7000	90	2671	21.47	163	2.04	1.71	1.88
108	11/10/38-1		180	5269	21.60	433	1.91	1.63	1.78
113	2			5242	21.66	476	1.71	1.52	1.62
114	3			5265	21.50	411	1.88	1.88	1.88
115	4			5228	21.63	482	1.62	1.58	1.60
116	5			5244	21.48	427	1.72	1.98	1.82
117	1		90	2668	21.57	179	1.98	1.48	1.71
118	2			2637	21.51	202	1.44	1.61	1.52
119	3			2655	21.52	186	1.69	1.58	1.60
120	4			2653	21.50	185	1.67	1.63	1.65
121	5			2662	21.55	183	1.84	1.52	1.67
KS-138---1	5/3/39--1	2000	160	2578	11.31	77	2.79	1.72	2.28
2	2			2550	11.40	126	1.63	1.09	1.44
3	3			2588	11.36	79	3.73	1.30	2.22
4	4			2568	11.42	111	2.24	1.04	1.68
7	5			2580			2.99		
6	6			2571	11.28	76	2.38	2.20	2.31
9	7			2581	11.33	78	3.02	1.56	2.25
8	8			2578	11.31	77	2.78	1.72	2.25
10	9			2586	11.42	93	3.53	1.04	2.03
5	10			2583			3.20		
11	5/4/39--1			2576	11.30	76	2.68	1.82	2.28
12	2			2577	11.35	87	2.74	1.38	2.09
13	3			2594	11.35	70	4.69	1.39	2.43
14	4			2589	11.31	65	3.92	1.73	2.53

Appendix C (Cont'd)

Program, Group, Serial Number	Date of Release, Run No.	Y Standard Altitude ft.	U Standard True Air Speed mi./hr.	X Standard Range ft.	T Standard Time of Flight sec.	λ Standard Trail ft.	C_X	C_T	C_λ
KS-138-15	5/4/39--5	2000	160	2580	11.26	62	3.00	2.61	3.00
16	6			2584			3.33		
17	7			2589			3.91		
18	8			2579	11.32	76	2.87	1.69	2.28
19	9			2583	11.36	84	3.21	1.30	2.12
20	10			2579			2.91		
1	7/11/39-1	20000		7622	38.43	1396	1.47	1.25	1.35
2	2			7622	38.69	1457	1.47	1.15	1.29
3	3			7643	38.07	1291	1.52	1.42	1.47
4	4			7690	38.19	1271	1.65	1.36	1.50
5	5			7622	38.50	1413	1.47	1.22	1.33
6	6			7694	38.58	1360	1.66	1.19	1.39
7	7			7587	38.32	1405	1.39	1.30	1.34
8	8			7694	38.38	1313	1.66	1.27	1.45
9	11/17/39-1			7666	38.23	1305	1.58	1.34	1.45
10	2			7600	38.55	1447	1.42	1.20	1.30
1	6/21/40-1	25000	200	10519			1.46		
2	2			10462			1.38		
4	4			10378			1.28		
5	5			10664	44.65	2433	1.72	1.01	1.27
7	7/5/40--2			10715			1.83		
8	3			10656	43.65	2149	1.70	1.28	1.46
9	4			10589	43.63	2210	1.58	1.29	1.41
10	5			10546	43.75	2288	1.51	1.25	1.37

Appendix D

Mean Standard Elements of Altitude Groups and Relations between the Ballistic Coefficients and the Altitude of Release

Appendix D
Table 1
Range

Y Standard Altitude ft.	U Standard True Air Speed mi./hr.	V Calibrated Indicated Air Speed Corresponding to Standard True Air Speed mi./hr.	N Number of Bombs	P Weight of Groups	X Mean Standard Range ft.	r_X Probable Error of Mean Standard Range ft.	C_X Ballistic Coefficient Corresponding to Mean Standard Range	r_{C_X} Probable Error of Ballistic Coefficient Corresponding to Mean Standard Range	C_{X_y} Value of Ballistic Coefficient from C:Y Relation	$X-X_f$ Mean Standard Range Minus Range Corresponding to C_{X_y} ft.
35000									1.41	
30000									1.43	
25000	200	134.8	8	0.56	10566	26.9	1.54	0.045	1.46	53
20000	160	116.7	10	0.88	7644	8.5	1.52	0.021	1.49	14
15000	160	126.3	11	0.77	6623	13.7	1.39	0.037	1.54	-51
12000	160	132.4	9	0.63	5980	8.4	1.45	0.029	1.59	-37
10000									1.64	
9000	160	138.8	11	0.77	5256	7.3	1.64	0.042	1.67	-6
7000	180	161.2	10	1.75	5246	3.2	1.73	0.022	1.75	13
7000	90	80.6	10		2670	5.1	2.03	0.128		11
6000	160	145.5	10	0.88	4347	6.2	1.76	0.061	1.82	27
5000									1.90	
2000	160	155.0	20	1.76	2580	1.4	2.93	0.110	2.82	2

Appendix D
Table 2
Time of Flight

Y Standard Altitude ft.	U Standard True Air Speed mi./hr.	V Calibrated Indicated Air Speed Corresponding to Standard True Air Speed mi./hr.	N Number of Bombs	P Weight of Groups	T Mean Standard Time of Flight sec.	r_T Probable Error of Mean Standard Time of Flight sec.	C_T Ballistic Coefficient Corresponding to Mean Standard Time of Flight	r_{C_T} Probable Error of Ballistic Coefficient Corresponding to Mean Standard Time of Flight	C_{T_y} Value of Ballistic Coefficient From C:Y Relation	$T-T_f$ Mean Standard Time of Flight Minus Time of Flight Corresponding to C_{T_y} sec.
35000									1.29	
30000									1.29	
25000	200	134.8	4	0.56	43.92	0.164	1.19	0.050	1.29	0.30
20000	160	116.7	10	0.88	38.39	0.042	1.26	0,018	1.29	0.06
15000	160	126.3	11	0.77	32.71	0.049	1.29	0.020	1.29	0.00
12000	160	132.4	5	0.63	29.06	0.018	1.24	0.013	1.29	0.07
10000									1.29	
9000	160	138.8	7	0.77	24.88	0.056	1.28	0.060	1.29	0.02
7000	180	161.2	10	1.75	21.60	0.015	1.64	0.034	1.29	-0.18
7000	90	80.6	10		21.52	0.029	1.60	0.071		-0.11
6000	160	145.5	10	0.88	20.04	0.022	1.33	0.040	1.29	-0.02
5000									1.29	
2000	160	155.0	15	1.76	11.34	0.008	1.47	0.066	1.29	-0.03

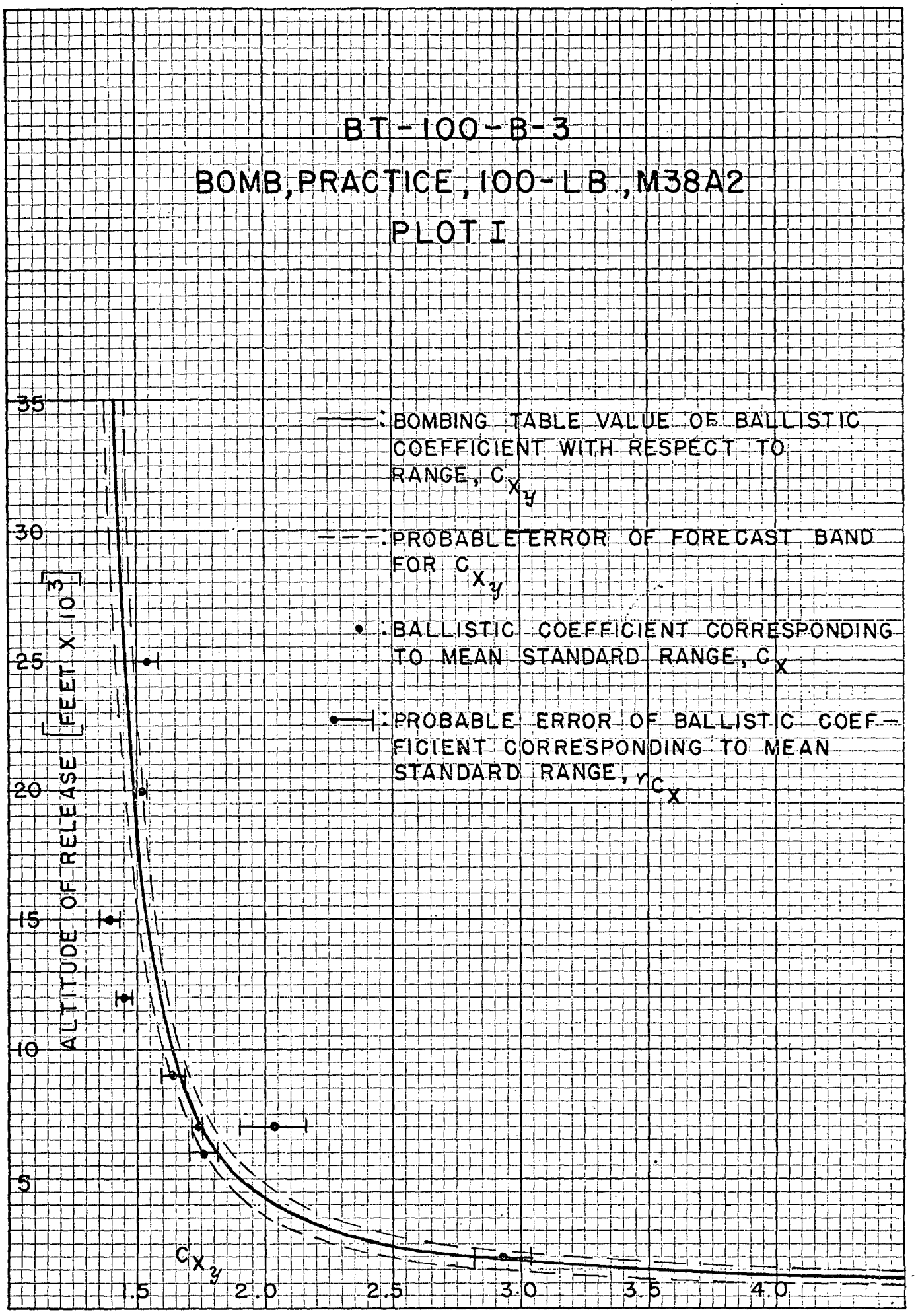
Appendix D
Table 3
TTrail

Y Standard Altitude ft.	U Standard True Air Speed mi./hr.	V Calibrated Indicated Air Speed Corresponding to Standard True Air Speed mi./hr.	N Number of Bombs	P Weight of Groups	λ Mean Standard Trail ft.	r_λ Probable Error of Mean Standard Trail ft.	C_λ Ballistic Coefficient Corresponding to Mean Standard Trail	r_{C_λ} Probable Error of Ballistic Coefficient Corresponding to Mean Standard Trail	C_{λ_y} Value of Ballistic Coefficient From C:Y Relation	$\lambda - \lambda_f$ Mean Standard Trail Minus Trail Corresponding to C_{λ_y} ft.
35000									1.32	
30000									1.33	
25000	200	134.8	4	0.56	2270	41.4	1.38	0.028	1.35	-42
20000	160	116.7	10	0.88	1366	14.3	1.38	0.015	1.37	-9
15000	160	126.3	11	0.77	1053	16.6	1.34	0.022	1.41	51
12000	160	132.4	5	0.63	822	15.0	1.37	0.026	1.45	41
10000									1.48	
9000	160	138.8	7	0.77	600	16.6	1.42	0.040	1.50	39
7000	180	161.2	10	1.75	457	5.4	1.69	0.028	1.56	-35
7000	90	80.6	10		170	4.5	1.80	0.048		-20
6000	160	145.5	10	0.88	357	3.9	1.55	0.017	1.60	12
5000									1.66	
2000	160	155.0	15	1.76	82	2.9	2.12	0.076	2.20	3

BT-100-B-3

BOMB, PRACTICE, 100-LB., M38A2

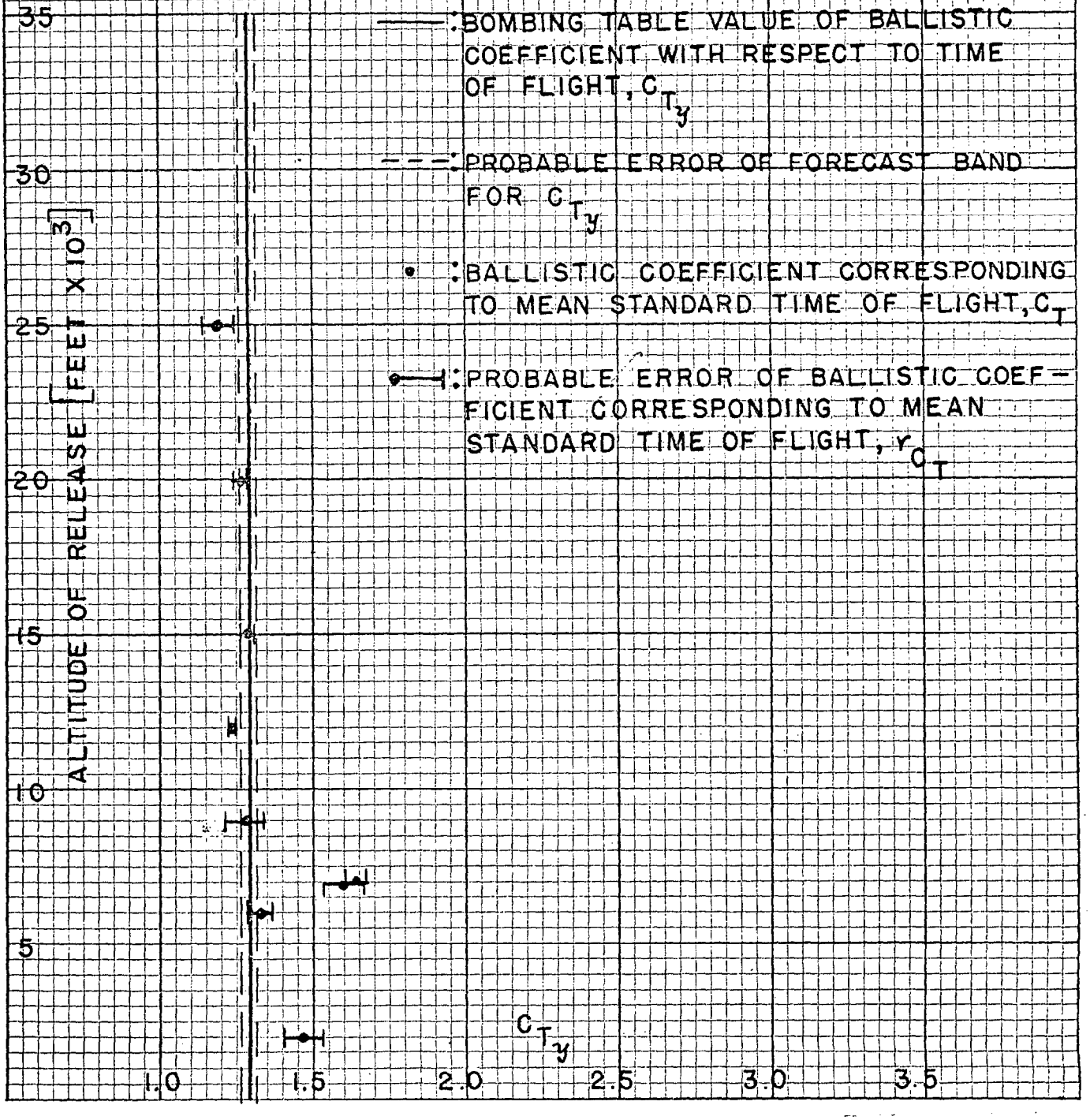
PLOT I



BT-100-B-3

BOMB, PRACTICE, 100-LB., M38A2

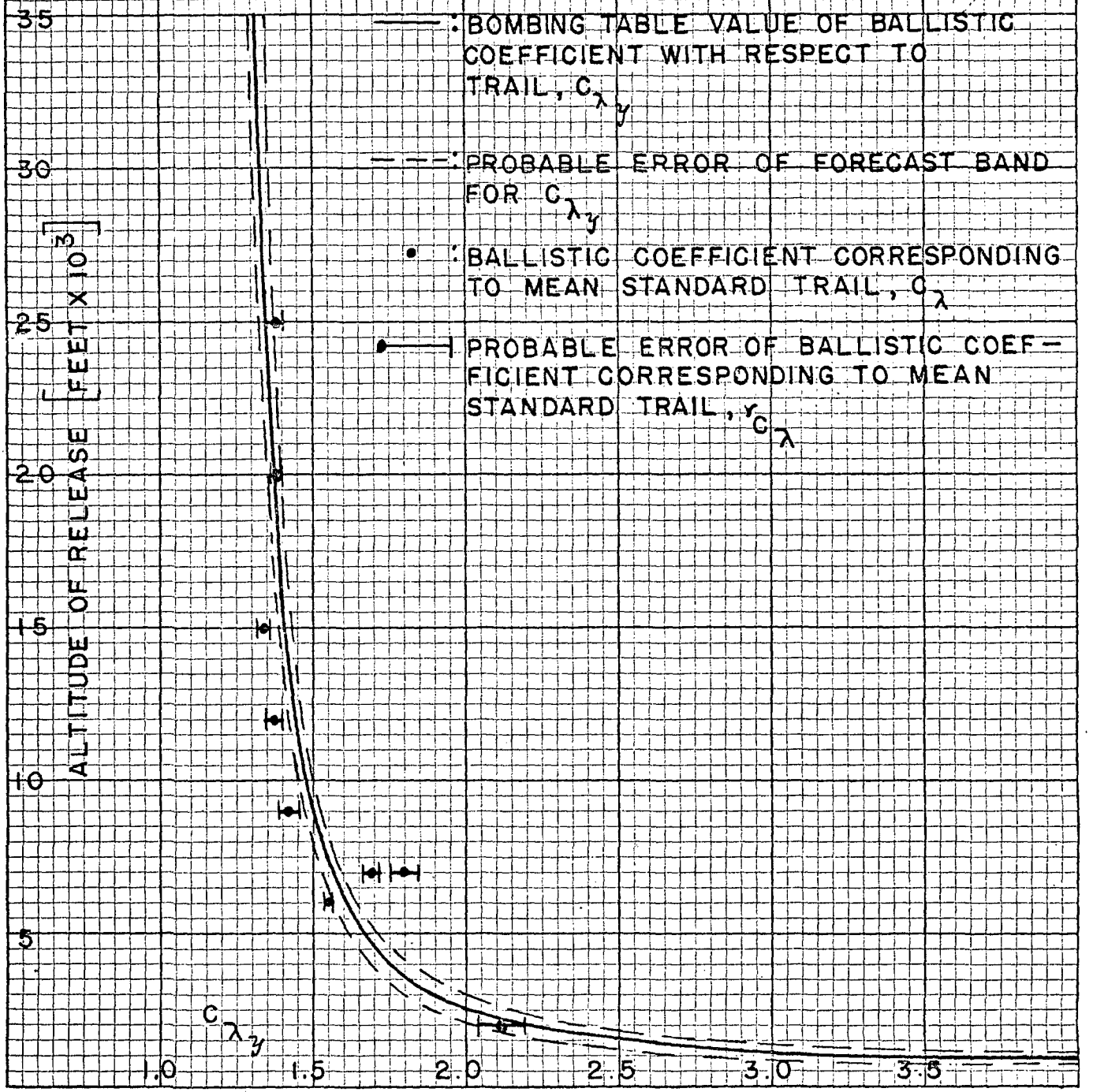
PLOT II



BT-100-B-3

BOMB, PRACTICE, 100-LB., M38A2

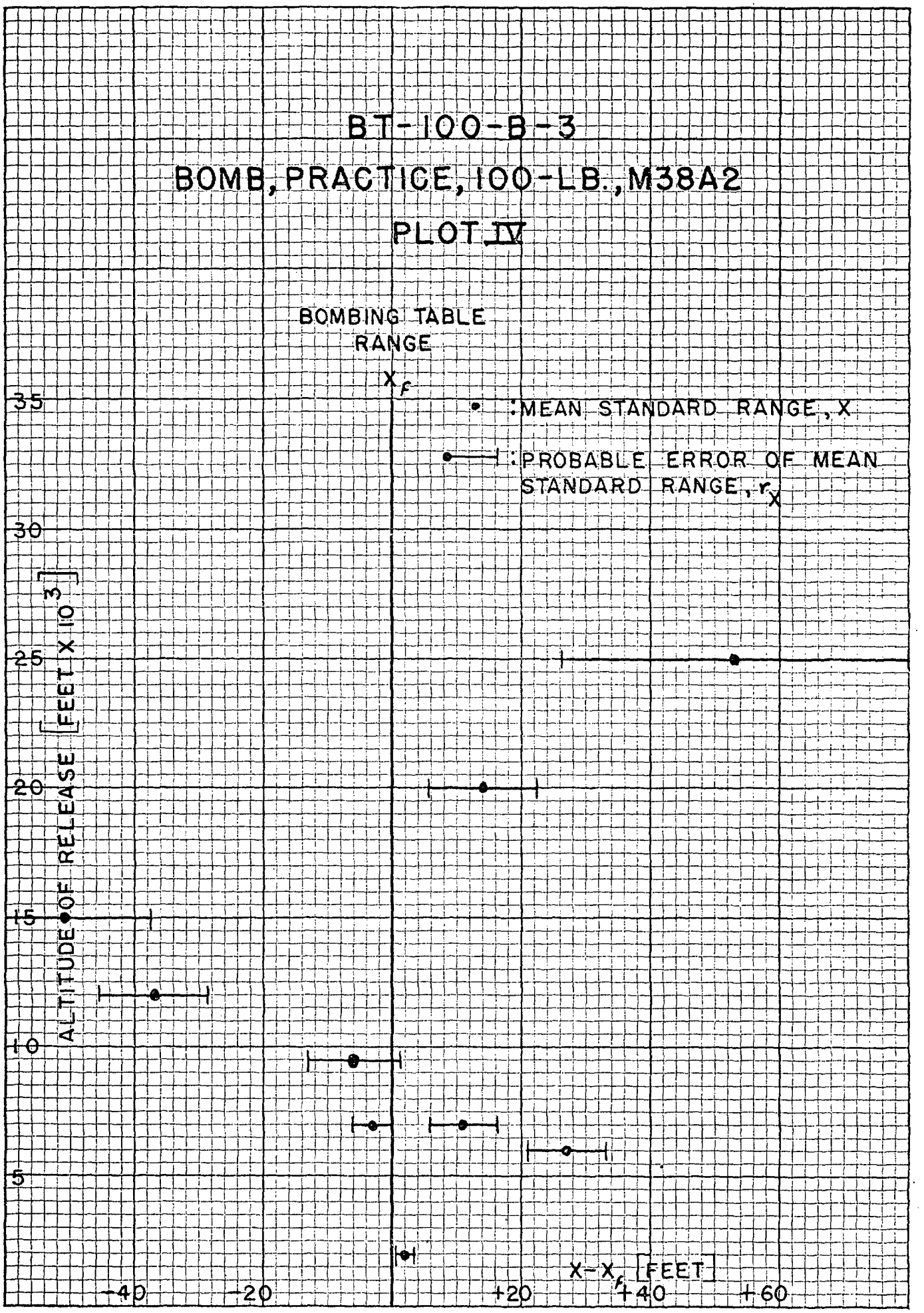
PLOT III



BT-100-B-3

BOMB, PRACTICE, 100-LB., M38A2

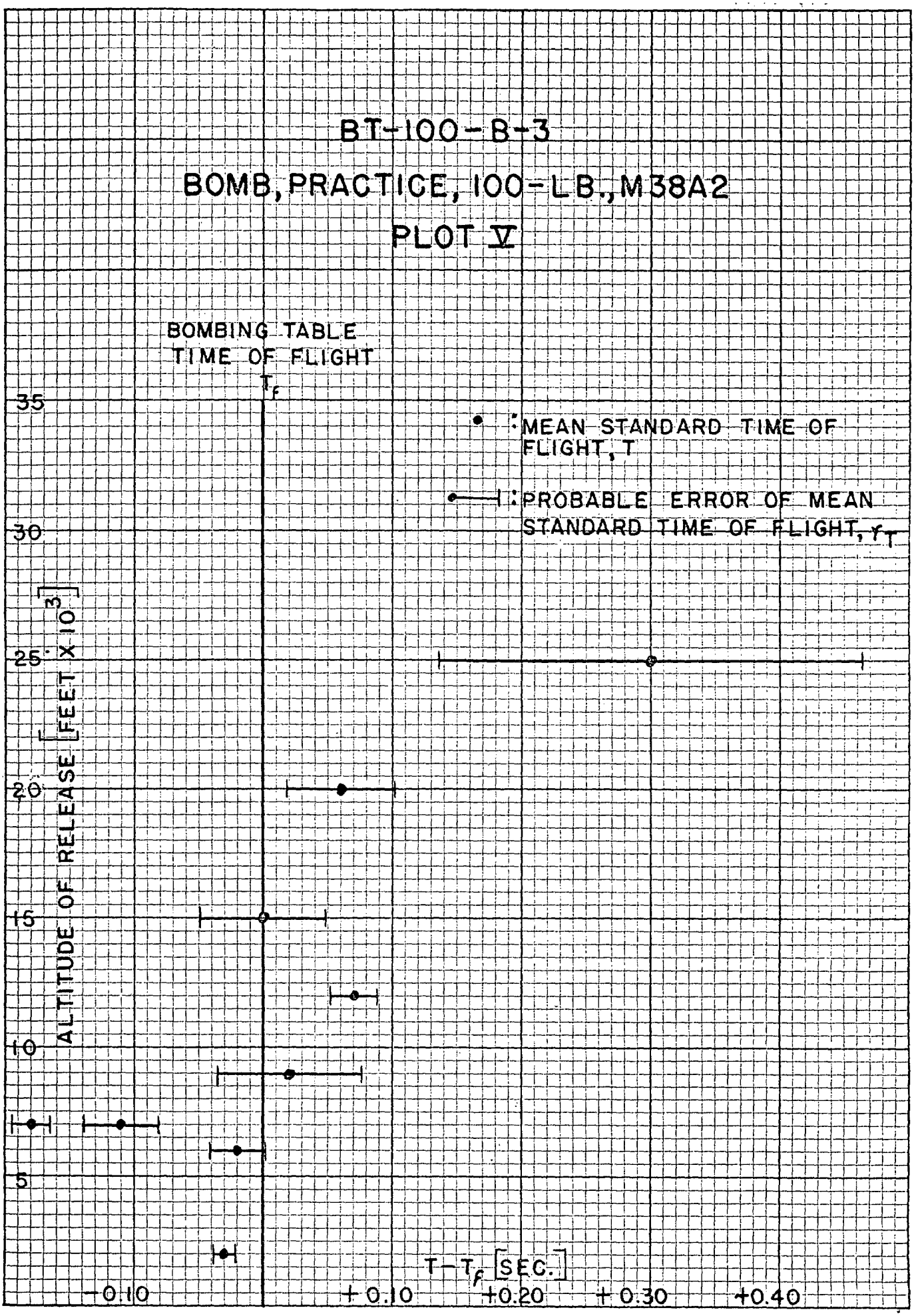
PLOT IV

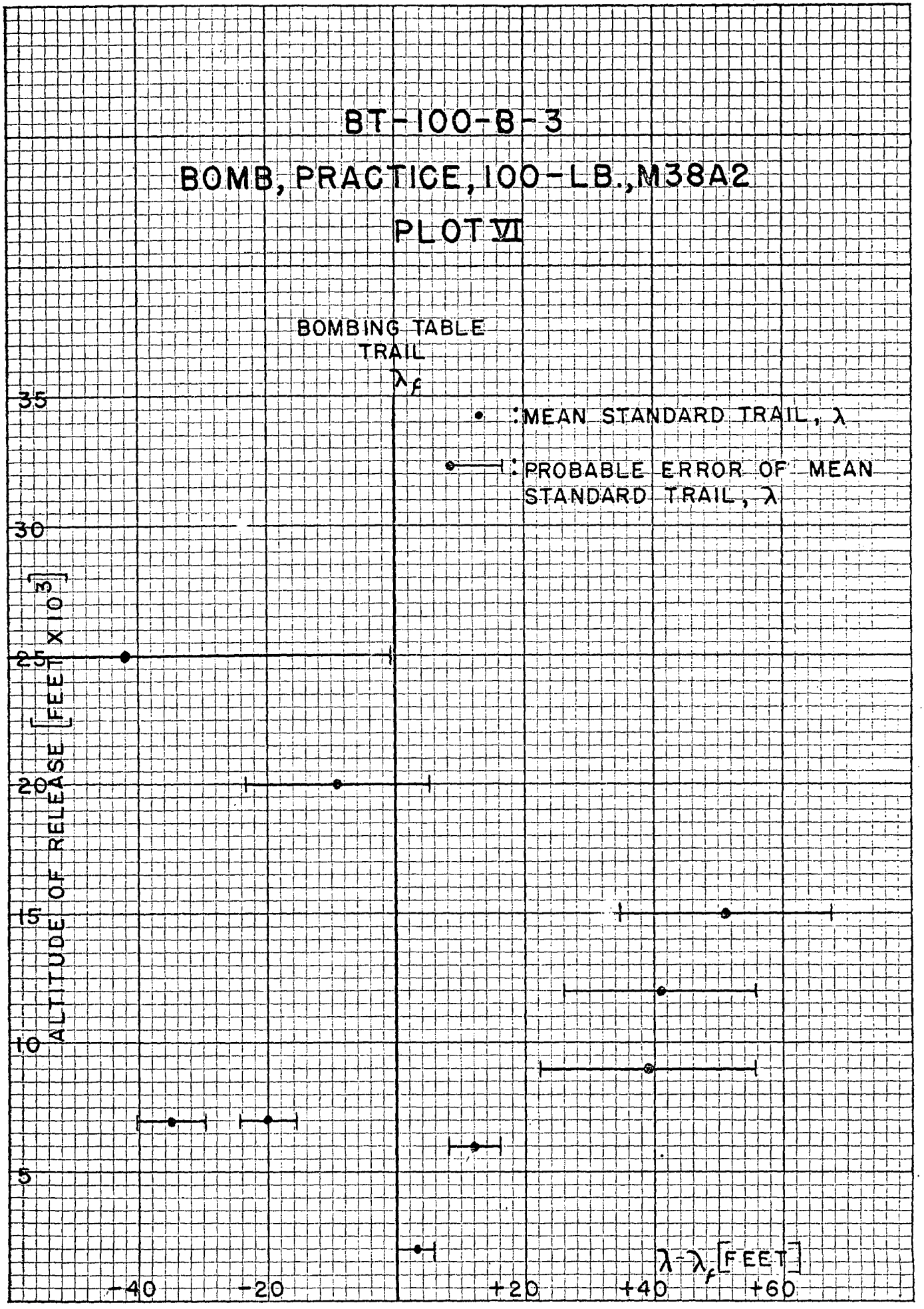


BT-100-B-3

BOMB, PRACTICE, 100-LB., M38A2

PLOT V




BT-100-B-3
BOMB, PRACTICE, 100-LB., M38A2
PLOT VI
BOMBING TABLE TRAIL λ_f
• : MEAN STANDARD TRAIL, λ
PROBABLE ERROR OF MEAN STANDARD TRAIL, λ
ALTITUDE OF RELEASE [FEET X 10^3]
35
30
25
20
15
10
5
$\lambda - \lambda_f$ [FEET]
-40
-20
+20
+40
+60

[redacted]

TITLE: Experimental Data Forming the Basis for the Bombing Tables BT-100-B-3 for the Bomb, Practice, 100 lb. M-38A2

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ABSTRACT:

This report contains the essential details of the experimental work, the computing methods and the experimental data upon which the bombing tables BT-100-B-3 for the M38A2 100-lb practice bomb are based. The bombs in this range bombing program were dropped from the B-18, B-4, B-4A, B-18A, and B-17B airplanes in accordance with the current standard bombing practice of the Air Corps using the standard bomb sight and a target in Bush River as an aiming point. The experimental data from which the ballistic coefficients with respect to range, time of flight and trail were determined, fell into 8 standard release altitudes: 25,000; 20,000; 15,000; 12,000; 9,000; 7,000; 6,000; and 2,000 feet. The methods used in range bombing, in obtaining the essential data, and in construction of the bombing tables are described. Graphs showing the results of range bombing, and the fitted ballistic coefficients as a function of the altitude of release are presented.

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DIVISION: Ordnance and Armament (22)

SECTION: Ballistics (12)

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